FINAL REPORT

Wildlife Issues Pertaining to Amphibians and the Western Pond Turtle *(Clemmys marmorata)* on the North Umpqua Hydroelectric Project Area

Marc P. Hayes

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This assessment reviews wildlife issues that pertain to amphibians and the western pond turtle on the North Umpqua Hydroelectric Project (NUHP) area. The NUHP influences an approximately 300,000 ac (121,500 ha) area in the headwaters of the North Umpqua River, which includes two of its major tributaries (the Clearwater River and Fish Creek). The project consists of a complex of eight dams and power developments as well as eight forebay and reservoir storage facilities linked with 37.3 mi (59.9 km) of canals (21.7 mi [34.9 km]), flumes (9.8 mi [15.7 km]), and penstocks and tunnels (5.8 mi [9.3 km]).

A landscape-level review and risk assessment that provided a generic address of the issues for elements like NUHP on a regional scale was completed within the Northwest Forest Plan, but even that analysis focused largely on terrestrial ecosystem processes and the effects linked to vegetation. In particular, the effects of structural features placed on the landscape (canals, dams, roads) on local wildlife issues and the processes associated with those features were not addressed because this was the purview of the appropriate lower-scale analysis. In their application for the NUHP relicensing (a major modified project), Pacificorp included amphibians and the western pond turtle in their technical report for the terrestrial resources study (Pacificorp 1995a). Amphibians were also indirectly addressed in their aquatic resources study (Pacificorp 1995e)[1]. Despite inclusion of these species in these reports and efforts made to detect the presence of federally listed and other sensitive taxa among them, gaps exist in the data concerning these species. Most prominent among these gaps are fundamental analyses that address the effects of NUHP-specific processes on existing conditions for the amphibians and the western pond turtle, and the risks those processes may pose to these taxa.

The purpose of this review is to identify the data gaps for amphibians and the western pond turtle, and address effects and risks relating to these species that are NUHP-process linked. This review will determine what information is needed to adequately address amphibians and the western pond turtle in context of watershed analysis and the NUHP environmental analysis and implementation. A likelihood assessment of additive and/or synergistic effects among NUHP features and alternative management activities nearby (timber harvest, roads or road density, and recreation) on amphibians and the western pond turtle will also be part of this review.

Method

<u>Background</u>: Pertinent literature on the 15 amphibians and the western pond turtle that may occur or are known to occur within the NUHP area was assembled. Emphasis was placed on species with federal status, state-level status, or on the US Forest Service Regional Sensitive Species List.

<u>Field evaluation</u>: A one-day field evaluation of NUHP facilities and landscape conditions was conducted on 10 May 1996 to provide a fundamental understanding of project layout and of project features that might influence amphibians and the western pond turtle. This evaluation was conducted with National Forest personnel familiar with project features.

<u>Document review</u>: Data contained in the Aquatic and Terrestrial Resource Studies for the NUHP that pertained directly or indirectly to amphibians and the western pond turtle were reviewed (Pacificorp 1995a, 1995b, 1995c, 1995d, 1995e, 1995f, 1995g). Review was subdivided into: (1) data that established the presence and the dispersion of amphibians and the western pond turtle within the project area, and (2) data that addressed how the layout

[1] Amphibians were addressed briefly within the fish entrainment studies.

of the NUHP and its processes might influence life history or population-level dynamics of these species.

Evaluation: This analysis establishes whether existing data were sufficient to determine the presence and dispersion of amphibians and western pond turtles within the project area. It includes identification of potential project-related risks to amphibians and the western pond turtle as well as the potential additive and/or synergistic effects with other activities to the connectivity, distribution, diversity, and persistence of the populations of these species. It includes recommendations of: (1) additional analyses, monitoring, and/or studies needed to fill gaps in understanding the level of risk or concerns to effectively manage the amphibians and western pond turtle in this system, and (2) the specific questions that should be asked and addressed in watershed analysis or future monitoring.

Review

The review is subdivided into species groupings having some parallel life history features related to reproduction. These include: (1) amphibians and the western pond turtle that use stillwater aquatic sites or adjacent uplands for reproduction, but having life history that ties them to both this aquatic and a terrestrial habitat type; (2) stream-dwelling amphibians that use some kind of flowing-water habitat for reproduction, but that also need adjacent mesic uplands for their terrestrial life stages; and (3) terrestrial amphibians the life stages of which occupy mesic terrestrial habitats for the balance of their life history.

Of the 15 native amphibians and the western pond turtle that might occur within the NUHP area, 11 amphibians and the western pond turtle were recorded during NUHP relicensing application studies (Table 1). One introduced amphibian, the bullfrog, was also recorded. Of the 15 native amphibians possible, NUHP studies recorded two of four flowing-water species, seven of eight stillwater species, and three of four terrestrial species.

Flowing-Water Species

Tailed frog *(Ascaphus truei)*: Tailed frog data are based on at least 80 individuals that represent at least 58 observations (Table 2). A precise number of tailed frog life stages cannot be determined because 24% (n = 30)[2] of the amphibians recovered during the fish entrainment studies were not identified (Pacificorp 1995e: p. 7-52, Table 7.4-1). This number is also ambiguous because observations from two sites are based on map data that represent an unspecified number of individuals (Table 2, footnote e). Of the at least 80 individuals recorded, 84% (n = 67) were observed during various surveys conducted in 1993, including amphibian-focused surveys (AMP); rare, threatened and endangered species (RTE) surveys (Pacificorp 1995b: Appendix 4.2-1: pp. 1-3); and electroshocking surveys (ESS) of Upper Slide and Warm Springs Creeks (Pacificorp 1995b: Appendix 5.3-5: p. 1; Pacificorp 1995a: Table 5.3-13: p. 5-94)[3]. Of the remaining 13 (17%), eight were obtained from fyke nets set in canals during fish entrainment studies (FES) during 1993-4 (Pacificorp 1995e: 7-52, Table 7.4-1), and the last five were observed along the Lemolo No. 2 waterway during 1994 (Pacificorp 1995b: 1994 Addendum: p. 17).

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[2] A minor error exists in Table 7.4-1 in Pacificorp (1995e; p. 7-52) that was not addressed in the 1994 Addendum to the Final Technical Report for Terrestrial Resources (Pacificorp 1995b) or elsewhere in the Aquatic Resource Study volumes (Pacificorp 1995c, 1995d, 1995e, 1995f, 1995g). The total number of Pacific giant salamanders observed (n = 4 in the "Total identified" column) is one less than the sum of the individuals observed in the three canals in which individuals were recorded (n = 5). The percentage of unidentified amphibians observed in the fish entrainment studies used in this statement assumes that the total number of individuals observed was five.

[3] Pacificorp (1995b: Appendix 5.3-5: p. 1) records 10 tailed frogs as having been electroshocked from Upper Slide (n = 6) and Warm Springs (n = 4) Creeks, whereas Pacificorp (1995a: Table 5.3-13: p. 5-94) records only four electroshocked individuals from Warm Springs. It is assumed that Upper Slide individuals were omitted from the footnotes in Table 5.3-13.

Table 1. Amphibians and turtles occurring or potentially occurring within the NUHP Area

Group	Common Name	Scientific Name	Recorded during NUHP relicensing application studies[a]
Flowing-water species	1) tailed frog S	*Ascaphus truei*	+ (80+)
	2) Pacific giant salamander	*Dicamptodon tenebrosus*	+ (114+)
	3) foothill yellow-legged frog (F)S	*Rana boylii*	–
	4) southern seep salamander S	*Rhyacotriton variegatus*	–
Stillwater species	1) northwestern salamander	*Ambystoma gracile*	+ (20+)
	2) long-toed salamander	*Ambystoma macrodactylum*	–
	3) boreal or western toad S	*Bufo boreas*	+ (147+)
	4) northwestern pond turtle *S	*Clemmys marmorata marmorata*	+ (25)
	5) Pacific chorus frog (= treefrog)	*Pseudacris (=Hyla) regilla*	+ (208+)
	6) northern red-legged frog *(F)S	*Rana aurora aurora*	+ (120+)
	7) cascades frog (F)S	*Rana cascadae*	+ (1543+)
	8) bullfrog (introduced species)	*Rana catesbeiana*	+ (unspecified)
	9) rough-skinned newt	*Taricha granulosa*	+ (15+)
Terrestrial species	1) clouded salamander S	*Aneides ferreus*	+ (17+)
	2) ensatina	*Ensatina eschscholtzii*	+ (4+)
	3) Dunn's salamander	*Plethodon dunni*	–
	4) red-backed salamander	*Plethodon vehiculum*	+ (5+)

[a] For species recorded, the number of observations recorded is indicated in parentheses. Observations means the number of individuals found except for red-legged and cascades frogs where 117 and 85 of the total represent egg masses, respectively. A plus following indicates that more individuals were or may have been seen because 30 unidentified amphibians were found during entrainment studies or eggs were found that would increase the total. The only species for which egg masses or packets were found that would significantly increase the total numbers observed are the Pacific chorus frog and the western toad.

* Species on the Forest Service's Regional Sensitive Species List. Note that tailed frog, foothill yellow-legged frog, cascades frog, and clouded salamander were on the interim Forest Service Regional Sensitive Species List during planning phases and some of the time the amphibian data were being gathered. As this list was never officially revised, only the northern red-legged frog and western pond turtle from the previous list are can be regarded as on the regional list.

F = Federal Candidate Species - Note: Parentheses indicated the species was a C2 Federal Candidate during planning phases of this project and the time the amphibian data were being gathered. The C2 category was recently eliminated, so none of the existing species are Federal Candidates at this time.

S = Oregon Sensitive Species

Note: Bullfrogs were simply recorded as having large populations at two of the seven sites at which the northwestern pond turtle was observed.

Table 2. Tailed frog *(Ascaphus truei)* observations based on NUHP relicensing application data

Drainage or Canal	Tributary or subunit	Life Stage[a] Larvae	Life Stage[a] Postmetamorph	Life Stage[a] Unknown	Total Observations[b]	Survey Type[c]	Survey Date(s)	Source of Data[d]
Clearwater No. 1 Canal	not applicable	?	?	2	2	FES	93/04/14-94/12/19	1
Clearwater No. 2 Canal	not applicable	?	?	2	2	FES	93/04/14-94/12/10	1
Fish Creek	Camas Creek	0	2	0	2	AMP	93/07/19	2,3
	Eva Creek	0	0	2[e]	2[e]	UNK	93/07/19	2,3
	Slipper Creek	0	0	1[e]	1[e]	UNK	93/07/22	2,3
Lemolo No. 2 Canal	not applicable	1	4	0	5	AMP/INC[f]	94/dates unspecified	4
		?	?	3	3	FES	93/07/07-94/12/10	1
Mowich Creek	none indicated	2	4	0	6	AMP	93/07/16-93/07/17	2
Slide Creek	Upper	4	11	0	15	AMP	93/07/13-93/07/19[g]	2,3,5,6,7
	Upper	2	6	0	8	RTE	93/07/date unspecified	6
	Upper	0	6	0	6	ESS[h]	93/09/date unspecified	2,6
Slide Creek Canal	not applicable	?	?	1	1	FES	93/07/21-94/12/10	1
Warm Springs Creek	none indicated	13	1	0	14	AMP	93/07/18-93/08/24[g]	2,5,6
		0	4	0	4	ESS[h]	93/09/date unspecified	2,6
White Mule Creek	none indicated	0	1	0	1	AMP	93/07/12	2,5,6
Unspecified	not applicable	5	3	0	8	RTE	93/07/date unspecified	6
	Totals	27	42	11	80			

[a] Life stage categories are mutually exclusive. Equivalent categories data sources are: larvae = YOY, postmetamorph = AFY or adult. A question mark (?) by itself means that category could be present because a category was not specified, all individuals are unknown.
[b] Observations is used to mean the number of individuals observed except where noted (see footnote on Fish Creek tributaries). In cases where different surveys were made of the same locality, individuals may have been resighted.
[c] Survey types are: amphibian surveys (AMP); electroshocking surveys (ESS); fish entrainment studies (FES); incidental observations (INC); rare, threatened, and endangered species surveys (RTE), and basis of data unknown (UNK).
[d] Data sources are: (1) Pacificorp (1995e: Appendix 3-1, Section 7, pp. 7-1 to 7-52); (2) Pacificorp (1995b: Appendix 5.3-5); (3) Pacificorp (1995b: Appendix 4.2-5, Map Sheet 5); (4) Pacificorp (1995b: 1994 Addendum, pp. 17-18); (5) Pacificorp (1995a: Table 5.3-13, p. 5-94); (6) Pacificorp (1995b: Appendix 4.2-1, pp. 1-3); (7) Pacificorp (1995b: Appendix 4.2-5, Map Sheet 6).
[e] Observations based on number of mapped elements, number of individuals was not specified.
[f] Of two survey types, during which type tailed frogs were found was not specified.
[g] Sampling did not include all days within the indicated interval.
[h] Indicated as incidental observations (INC) in data source (6) above (see footnote d).

Graphical and tabular presentation of tailed frog data is not consistent with the assertion that tailed frogs were "found in nearly every stream surveyed in the study area" (Pacificorp 1995a: 4-40, 4-41). The graphical presentation maps only data from Upper Slide and Fish Creeks, and data from the latter has no tabular equivalent. Tailed frogs were observed in five creek systems: Fish, Mowich, Slide, Warm Springs, and White Mule. Tailed frog life stages found in the Clearwater No. 2, Slide Creek, and Lemolo No. 2 canals may have originated in the Mowich, Fish, and Warm Springs creek systems, respectively. Tailed frogs found in the Clearwater No. 1 canal may come from a stream source other than those already identified. Surveys focused in streams associated with proposed diversions biases the distributional data. Tailed frog surveys were conducted during the interval suggested as optimal[4], but were completed during the daytime. The species is known to be nocturnal (Nussbaum et al, 1983) and the Oregon Department of Fish and Wildlife has recommended nocturnal surveys for adequate detection of tail frogs in its most recent protocol guidelines; diurnal surveys can miss low to moderate-density populations (Hayes, unpubl. data). As such, understanding tailed frog distribution within the NUHP area is fragmentary. Tailed frog may be common in most streams within the NUHP area, as Pacificorp (1995a: 4-40, 4-41) implies, but data are unavailable to support this conclusion.

Life stage or age structure data is difficult to interpret because of lack of categorization or non-parallelism. The eight tailed frogs identified that were captured during fish entrainment studies (Pacificorp 1995e: pp. 7-51, 7-52) and the 10 tailed frogs from electroshocking surveys of Upper Slide and Warm Springs Creeks in 1993 (Pacificorp 1995b: Appendix 5.3-5: p. 1) were not placed in a life stage or age-based category. Life stage or age-based categories for some 1993 and 1994 survey data were not parallel. Of 64 tailed frog life stages seen during the 1993 surveys, 26 were classed as young of the year (YOY) and 38 as after the first year (AFY; Pacificorp 1995b: Appendix 4.2-1: pp. 1-3), whereas four of five tailed frog life stages seen along the Lemolo No. 2 waterway during 1994 were termed adult; the remaining individual was not characterized (Pacificorp 1995b: 1994 Addendum: p. 17). Allocation of 1993 animals was based on larvae being YOY and postmetamorphic individuals being AFY (K. Engel, pers. comm.)[5]; the criteria used to allocate 1994 survey animals as adults are unknown. In context of the long interval tailed frogs likely require to reach sexual maturity (see Appendix), postmetamorphic life stages observed in both years represent ambiguous groupings.

Pacific giant salamander *(Dicamptodon tenebrosus)*: Pacific giant salamander data are based on at least 118 individuals that represent an unspecified number of observations (Table 3). The number of Pacific giant salamanders is imprecise because 24% (n = 30) of the amphibians recovered during the fish entrainment studies were not identified (Pacificorp 1995e: p. 7-52, Table 7.4-1). Of at least 118 Pacific giant salamander life stages recorded, 96% (n = 113) were observed during various AMP, RTE, and ESS surveys conducted in 1993 (Table 3). The five remaining individuals (4%) were recorded during entrainment studies conducted in 1993-4. Where a life stage was noted, most individuals ($^{73}/_{78}$, 94%) were larvae; the remainder were metamorphosed individuals. This kind of data is typical for diurnal searches because adults are cryptic and largely nocturnal. Electroshocking and the fyke nets used in the entrainment studies favor sampling larvae, so the 40 individuals for which a life stage was not specified in these studies would not likely change these data.

Pacific giant salamanders were recorded from four of the five creek systems in which tailed frogs were found (all except White Mule), but they were also found in three systems from which tailed frogs were unrecorded (Fallen Mountain, Medicine, and Watson Creeks). As

[4] Corn and Bury (1991) are cited as the support for this choice of interval for stream surveys, but the citation was omitted from the literature cited section in Pacificorp (1995a).

[5] Crossing-matching Pacificorp (1995b: Appendix 5.3-5: p. 1) with the data for the same localities in Appendix 4.2-1 (pp. 1-3 of the same volume) also indicates that adult and larvae meant AFY and YOY, respectively.

Table 3. Pacific giant salamander *(Dicamptodon tenebrosus)* observations based on NUHP relicensing application data

Drainage or Canal	Tributary or subunit	Life Stage[a] Larvae	Postmetamorph	Unknown	Total Observations[b]	Survey Type[c]	Survey Date(s)	Source of Data[d]
Clearwater No. 1 Canal	not applicable	?	?	3	3	FES	93/04/14-94/12/19[e]	1
Clearwater No. 2 Canal	not applicable	?	?	1	1	FES	93/04/14-94/12/10[e]	1
Fallen Mountain Creek	none indicated	4	0	0	4	AMP	93/07/15	2
Fish Creek	Camas Creek[f]	8	3	0	11	AMP	93/07/19	2
	Eva Creek[f]	0	1	0	1	AMP	93/07/19	2
	Slipper Creek	2	0	0	2	AMP	93/07/22	2
Medicine Creek	none indicated	4	0	0	4	AMP	93/07/21	2
Mowich Creek	none indicated	7	0	0	7	AMP	93/07/16-93/07/17	2
Slide Creek	Lower	2	0	0	2	AMP	93/07/19	2,3
	Lower	0	0	2	2	ESS	93/09/date unspecified	2
	Upper	33	1	0	34	AMP	93/07/13-93/07/19[e]	2,3
	Upper	0	0	33	33	ESS	93/09/date unspecified	2
Slide Creek Canal	not applicable	?	?	1	1	FES	93/07/21-94/12/10[e]	1
Warm Springs Creek	none indicated	2	0	0	2	ESS	93/09/date unspecified	2
Watson Creek	none indicated	7	0	0	7	AMP	93/07/20-93/07/21	2
	Totals	69	5	40	114			

[a] Life stage categories are mutually exclusive. Equivalent categories data sources are: larvae = YOY, postmetamorph = AFY or adult. A question mark (?) by itself means that category could be represent because a category was not specified, all individuals are unknown.

[b] Observations is used to mean the number of individuals observed. In cases where different surveys were made of the same locality, individuals may have been resighted.

[c] Survey types are: amphibian surveys (AMP); electroshocking surveys (ESS); fish entrainment studies (FES); incidental observations (INC); and basis of data unknown (UNK).

[d] Data sources are: (1) Pacificorp (1995e: Appendix 3-1, Section 7, pp. 7-1 to 7-52); (2) Pacificorp (1995b: Appendix 5.3-5); (3) Pacificorp (1995a: Table 5.3-13, p. 5-94)..

[e] Sampling did not include all days within the indicated interval.

[f] The data indicated here are conservatively drawn from Pacificorp (1995b:Appendix 5.3-5), but conflict with the number of Pacific giant salamanders recorded in Pacificorp (1995b: Appendix 5.3-3), which reports a total of 20 individuals for Camas and Eva Creeks combined.

with tailed frog, the distributional data are biased as a result of surveys focused in systems associated with previously proposed diversions.

Foothill yellow legged frog *(Rana boylii)*: No life stages of the foothill yellow-legged frog were observed during relicensing studies (Pacificorp 1995a: Appendix 4-1: p. 4-38). The seasonal temperature regime (Pacificorp 1995h, 1995i) of structural suitable flowing-water habitats (see Appendix) within the primary project area (e.g., above Soda Springs) may be consistently too cold to support this species. This species has been recorded from the North Umpqua River downstream from the primary project area, but not as result of the NUHP studies (J. Myers in Pacificorp 1995a). Because the foothill yellow-legged frog is vulnerable to fluctuations in water regime, habitat loss (bars) because of loss or reduction of fluvially linked geomorphologic processes (Lind et al. 1996), and may be vulnerable to predation from exotic bullfrogs and fishes (Hayes and Jennings 1988), its absence from the NUHP area between Soda Springs and Island Campground may indicate direct or indirect effects as a result of these factors. This alternative is confounded with fragmentary surveys that were conducted in this part of the North Umpqua. Of 13 river or river-edge locations surveyed in ca. 16 river miles along the North Umpqua (Pacificorp 1995b: Appendix 4.1-1, Map Sheets 4 and 5), five were considered to have potential breeding habitat for foothill yellow-legged frogs. Surveys of the North Umpqua for this species were not completed at or downstream from the intersection of the river with a number of key tributaries streams (e.g., Apple, Copeland, Dog, and Jack Creeks), sites known to have a higher probability of supporting local populations of foothill yellow-legged frogs (Hayes and Jennings 1988). Surveys being delayed because of high flows through June 1993 also had the potential to miss eggs potentially subject to scour from high flows (Lind et al. 1996); typically, the egg-laying interval occurs April through June. Thus, it is unclear whether this species was not observed because of insufficient surveys or because it is really not present.

Southern seep (formerly **Olympic**, also called **torrent) salamander** *(Rhyacotriton variegatus)*: No life stages of this seep salamander were seen during relicensing studies (Pacificorp 1995a: Appendix 4-1: p. 4-41). However, the key reproductive habitat of this species are seeps with a characteristic substrate structure (see Appendix), and the protocol for surveys in the relicensing studies did not emphasize examining this focal habitat. In addition, the recent discovery of this species at increasingly inland positions in the South Umpqua (C. Barkhurst, pers. comm.) through an address of its focal habitat indicates that this species may not have been satisfactorily addressed in the relicensing studies.

Stillwater Species

Northwestern salamander *(Ambystoma gracile)*: Northwestern salamander data are based on few observations: at least 20 individuals and one egg mass found at five sites (Table 4). The estimate is imprecise because 24% (n = 30) of the amphibians recovered during the fish entrainment studies were not identified (Pacificorp 1995e: p. 7-52, Table 7.4-1). Notably, most (85%, $^{17}/_{20}$) northwestern salamanders were taken from fyke nets used to determine fish entrainment patterns. The northwestern salamander was one of the only two permanent water-linked amphibians (western toad is the other) the egg masses of which were found in NUHP reservoirs[6]. An undetermined number of northwestern salamander egg masses were found in Toketee Lake (Table 4). Decline in northwestern salamander numbers in a downstream direction through two Clearwater Canals indicates that entrained individuals originate from an upstream reproductive site, possibly Stump Lake. Similarly, individuals in the Slide Creek Canals may indicate that an unidentified

[6] Pacific chorus frog egg packets were recorded from several NUHP impoundments (see account for this species). However, this species has a flexible life history that does not tie it exclusively to permanent-water; rather, it may deposit eggs at sites with highly variable hydroperiod (see Appendix). Moreover, most locations in impoundments in which Pacific chorus frog eggs were found were in protected shallows, often isolated from the main body of water.

Table 4. Stillwater-breeding salamander observations based on NUHP relicensing application data

General Area	Tributary or subunit	Life Stage[a] Eggs	L or PM	Unknown	Total Observations[b]	Survey Type[c]	Survey Date(s)	Source of Data[d]
Northwestern Salamander *(Ambystoma gracile)*								
Clearwater No. 1 Canal	not applicable	?	?	8	8	FES	93/04/14-94/12/19[e]	1
Clearwater No. 2 Canal	not applicable	?	?	2	2	FES	93/04/14-93/07/19[e]	1
Slide Creek Canal	not applicable	?	?	9	9	FES	93/07/21-94/12/10[e]	1
Soda Spring Development	not specified	?	?	1	1	INC	92-93/date not specified	2
Toketee Lake	not applicable	X	0	0	X	INC	93/date unspecified	3
	Totals	?	?	20	20X			
Rough-skinned Newt *(Taricha granulosa)*								
Clearwater No. 1 Canal	not applicable	?	?	2	2	FES	93/04/14-94/12/19[e]	1
Lemolo No. 1 Canal	not applicable	?	?	1	1	FES	93/04/11-94/12/10[e]	1
Soda Spring Development	not specified	?	?	4	4	INC	92-93/date not specified	2
Slide Creek Canal	not applicable	?	?	7	7	FES	93/07/21-94/12/10[e]	1
Upper Slide Creek	not specified	?	?	1	1	SEA	93/summer/date unspecified	4
	Totals	?	?	15	15			

[a] Life stage categories are mutually exclusive. Equivalent category data sources are: eggs = egg mass, L or PM = larvae or postmetamorphs. A question mark (?) by itself means that category could be present because a category was not specified, all individuals are unknown. An X indicates egg masses were observed, but not quantified.
[b] Observations is used to mean the number of individuals observed. In cases where different surveys were made of the same locality, individuals may have been resighted.
[c] Survey types are: fish entrainment studies (FES); incidental observations (INC); and seasonal surveys (SEA).
[d] Data sources are: (1) Pacificorp (1995e: Appendix 3-1, Section 7, pp. 7-1 to 7-52); (2) Pacificorp (1995b: Appendix 5.3-8, p. 5-76); (3) Pacificorp (1995b: Appendix 5.3-5, p. 5-56); and (4) Pacificorp (1995a: Table 5.3-10, p. 5-84).
[e] Sampling did not include all days within the indicated interval.

reproductive site exists upstream from this location. Lack of allocation of individuals from entrainment studies to larval vs. postmetamorphic life stages prevents distinguishing whether none, some, or all individuals could have entered the canal below the upstream stillwater source.

Long-toed salamander *(Ambystoma macrodactylum)*: No long-toed salamander life stages were observed during relicensing studies (Pacificorp 1995a, 1995b), including the fish entrainment studies (Pacificorp 1995e: Section 7, pp. 7-1 to 7-52). This species may have been among the 30 unidentified amphibians recorded during the entrainment studies, but its absence from the relicensing studies is peculiar since it is common and widespread at both lower (Nussbaum et al. 1983) and higher elevations (e.g., Horse and Teal Lakes near Diamond Lake; M. Hayes, pers. observ., 1996). This species is vulnerable to fish predation (see Appendix), so its absence from NUHP studies may indicate an inability to establish because of the exotic fish populations in the system. However, this alternative is confounded with potential detectability and identification problems. Nocturnal adults are rarely encountered during diurnal surveys, and young larvae and eggs can be easily mistaken for those of the northwestern salamander and Pacific chorus frog, respectively.

Western toad *(Bufo boreas)*: Western toads seen within the project area were restricted to Stump Lake and Clearwater Canals Nos. 1 and 2 (Table 5). Stump Lake is a known site of reproduction, and the decline in toad numbers from the two Clearwater Canals in a downstream direction implies entrainment that may ultimately originate from Stump Lake. This pattern parallels the northwestern salamander. As with northwestern salamander, lack of allocation of individuals from entrainment studies to larval vs. postmetamorphic life stages prevents distinguishing whether none, some, or all individuals could have entered the canal below the upstream stillwater source. Like northwestern salamander, its unpalatable larval stage (see Appendix) allows it to occur with predatory fishes.

Western pond turtle *(Clemmys marmorata)*: Few pond turtle observations were made during relicensing studies (Pacificorp 1995a). Observations were restricted to seven locations, one of which was associated with a project impoundment (e.g., Stink Hole), five of which were in ponds located in the transmission right-of-way corridor, and the remaining site was an unspecified location in the secondary study area (Table 6). At all sites, only turtles described as adults were observed. Two of the seven sites, neither of which was Stink Hole, were described as harboring large mixed (adult and juvenile) populations of bullfrogs (Pacificorp 1995a: p. 4-39).

Pacific chorus frog *(Pseudacris regilla)*: Pacific chorus frog data are based on over 208 observations from 14 locations (Table 7). Evidence of recent reproduction (eggs or larvae) was observed at only four sites (Stump Lake, Clearwater No. 2 Forebay, Lemolo No. 1 Diversion, and Lemolo No. 2 Canal). The extend of reproduction at those sites is unknown because the number of the respective life stages was unspecified. The data are likely to underestimate the extent to which this species occurs within the project area as it was not recorded on some surveys that addressed other amphibians (e.g., RTE surveys). However, because this species is vulnerable to fish predation when reproduction occurs in permanent water with fishes, this alternative is partly confounded with the possibility that this species was unable to reproduce successfully in NUHP stillwater sites with fish.

Northern red-legged frog *(Rana aurora aurora)*: Northern red-legged frog data are based on observations of 117 egg masses and three postmetamorphic individuals found across 11 sites (Table 8). Focus on egg mass surveys and movement of this species to upland sites soon after reproduction explains the large egg mass to postmetamorphic individual ratio observed. Significant reproduction (>30 egg masses) was observed at three sites (Upper Mountain Meadows, a Fish Creek system pond, and an unspecified pond in the Secondary Study Area), whereas limited reproduction (≤3 egg masses) was observed at three additional sites (Mill Creek, and at two sites in the Secondary Study Area near Fairview and Hill Creeks, respectively). Based on these data, reproduction

Table 5. Western toad *(Bufo boreas)* observations based on NUHP relicensing application data

General Area	Tributary or subunit	Life Stage[a] Eggs	Larvae	PM	Unknown	Total Observations[b]	Survey Type[c]	Survey Date(s)	Source of Data[d]
Western toad *(Bufo boreas)*									
Clearwater No. 1	Stump Lake	X	10	0	0	10X	SEA	93/08/date unspecified	1,2,3
	Stump Lake	0	100	0	0	100	SEA	93/08/date unspecified	1,2,3
	Stump Lake	0	0	20	0	20	INC	93/04/date unspecified	1,2,3
Clearwater No. 1 Canal	not applicable	?	?	?	12	12	FES	93/04/14-94/12/19[e]	4
Clearwater No. 2 Canal	not applicable	?	?	?	5	5	FES	93/04/14-94/12/10[e]	4
	Totals	X	100	30	17	147X			

[a] Life stage categories are mutually exclusive. Eggs refers to pre-hatching embryonic stages, larvae are the post-hatching to pre-metamorphic aquatic stages, whereas postmetamorphs refers to the postmetamorphic stages whether sexually mature or not. A question mark (?) by itself means that category could be present because a category was not specified, all individuals are unknown. An X indicates the life stage was observed, but the numbers were not counted.
[b] Observations is used to mean the number of individuals observed. In cases where different surveys were made of the same locality, individuals may have been resighted.
[c] Survey types are: fish entrainment studies (FES); incidental observations (INC); and seasonal surveys (SEA).
[d] Data sources are: (1) Pacificorp (1995a: Table 5.3-3, p. 5-38); (2) Pacificorp (1995b: Appendix 4.2-1, p. 3); (3) Pacificorp (1995b: Appendix 4.2-5, Map Sheet 6); and (4) Pacificorp (1995e: Appendix 3-1, Section 7, pp. 7-1 to 7-52).
[e] Sampling did not include all days within the indicated interval.

Table 6. Northwestern pond turtle *(Clemmys marmorata marmorata)* observations based on NUHP relicensing application data

General Area	Specific Location	Life Stage[a] Juveniles	Life Stage[a] Adults	Total Observations[b]	Survey Type[c]	Survey Date(s)[d]	Source of Data[e]
Site A	Transmission-ROW	0	1	1	INC	92/06/date unspecified	1
Site B	Transmission-ROW	0	2	2	INC	93/05/date unspecified	1
Site C	Transmission-ROW	0	1	1	INC	93/06/date unspecified	1
Site D	Transmission-ROW	0	6	6	RTE	93/06/date unspecified	1
Site D	Transmission-ROW	0	3	3	INC	93/08/date unspecified	1
Site E	Transmission-ROW	0	2	2	INC	93/07/date unspecified	1
Toketee Lake	Stink Hole	0	2	2	INC	93/07/date unspecified	1,2,3
Site F	not specified	0	2	2	INC	93/05/date unspecified	1
	not specified	0	6	6	INC	93/06/date unspecified	1
	Totals	0	25	25			

[a] Life stage categories are mutually exclusive. Equivalent categories data sources are: juveniles = YOY, adults = AFY.
[b] Observations means numbers of individuals observed. Some individuals at revisited may have been resighted in the tallies.
[c] Survey types are: incidental observations (INC); and rare, threatened, and endangerered species surveys (RTE).
[d] Actual survey for a given site may not include all days within the indicated interval.
[e] Data sources are: (1) Pacificorp (1995b: Appendix 4.2-1, pp. 7); (2) Pacificorp (1995a: Appendix 4.1, pp. 4-39); and (3) Pacificorp (1995a: Table 5.3-5, p. 5-56).

Table 7. Pacific chorus frog *(Pseudacris [=Hyla] regilla)* observations based on NUHP relicensing application data

General Area	Tributary or subunit	Life Stage[a] Egg	Larvae	PM	Unknown	Total Observations[b]	Survey Type[c]	Survey Date(s)	Source of Data[d]
Clearwater No. 1	Stump Lake	X	0	1	0	1X	SEA	93/summer/date unspecified	1
	waterway	0	0	2	0	2	INC	93/date unspecified	1
Clearwater No. 1 Canal	not applicable	0	0	0	1	1	FES	93/04/14-94/12/19[e]	2
Clearwater No. 2	forebay	X	0	51	0	51X	INC	93/date unspecified	3
Clearwater No. 2 Canal	not applicable	0	0	0	1	1	FES	93/04/14-94/12/10[e]	2
Fish Creek	waterway	0	0	50	0	50	INC	93/date unspecified	4
Lemolo No. 1	diversion	0	P	41	A	41PA	INC	93/date unspecified	5
Lemolo No. 1 Canal	not applicable	0	0	0	15	15	FES	93/04/11-94/12/10[e]	2
Lemolo No. 2	waterway	0	P	0	0	P	INC	93/date unspecified	6
Lemolo No. 2 Canal	not applicable	0	0	0	1	1	FES	93/07/07-94/12/10[e]	2
Slide Creek	Lower	0	0	2	0	2	SEA	93/spring/date unspecified	7
	Upper	0	0	2	A	2A	SEA	93/fall/date unspecified	7
Slide Creek Canal	not applicable	0	0	0	4	4	FES	93/07/21-94/12/10[e]	2

[a] Life stage categories are mutually exclusive. Eggs refers to pre-hatching embryonic stages, larvae are the post-hatching to pre-metamorphic aquatic stages, whereas postmetamorphs refers to the postmetamorphic stages whether sexually mature or not. A question mark (?) by itself means that category could be present because a category was not specified, all individuals are unknown. An X indicates the life stage was observed, but the numbers were not counted. A P indicates larvae were present, but not counted. An A indicates auditory detection (calls).

[b] Observations is used to mean the number of individuals observed. In cases where different surveys were made of the same locality, individuals may have been resighted.

[c] Survey types are: fish entrainment studies (FES); incidental observations (INC); and seasonal surveys (SEA).

[d] Data sources are: (1) Pacificorp (1995a: Table 5.3-3, p. 5-38); (2) Pacificorp (1995e: Appendix 3-1, Section 7, pp. 7-1 to 7-52); (3) Pacificorp (1995a: Table 5.3-4, p. 5-50); (4) Pacificorp (1995a: Table 5.3-6, p. 5-67); (5) Pacificorp (1995a: Table 5.3-1, p. 5-21); (6) Pacificorp (1995a: Table 5.3-2, p. 5-28); and (7) Pacificorp (1995a: Table 5.3-10, p. 5-84).

[e] Sampling did not include all days within the indicated interval.

Table 7. Pacific chorus frog *(Pseudacris [=Hyla] regilla)* observations based on NUHP relicensing application data (continued)

General Area	Tributary or subunit	Life Stage[a] Egg	Larvae	PM	Unknown	Total Observations[b]	Survey Type[c]	Survey Date(s)	Source of Data[d]
Soda Springs	diversion	0	0	2	0	0	INC	93/date unspecified	1
Stink Hole	not applicable	0	0	32	A	32A	INC	93/date unspecified	2
Toketee Lake	not specified	0	0	3	22A	3A	INC	93/date unspecified	2
	Totals	X	P	186	22A	208XPA			

[a] Life stage categories are mutually exclusive. Eggs refers to pre-hatching embryonic stages, larvae are the post-hatching to pre-metamorphic aquatic stages, whereas postmetamorphs refers to the postmetamorphic stages whether sexually mature or not. A question mark (?) by itself means that category could be present because a category was not specified, all individuals are unknown. An X indicates the life stage was observed, but the numbers were not counted. An A indicates auditory detection (calls).

[b] Observations is used to mean the number of individuals observed. In cases where different surveys were made of the same locality, individuals may have been resighted.

[c] Survey type is incidental observations (INC).

[d] Data sources are: (1) Pacificorp (1995a: Table 5.3-8, p. 5-76); and (2) Pacificorp (1995a: Table 5.3-5, p. 5-56).

[e] Sampling did not include all days within the indicated interval.

Table 8. Northern red-legged frog *(Rana aurora aurora)* observations based on NUHP relicensing application data

General Area	Specific Location	Life Stage[a] Eggs	Postmetamorph	Total Observations[b]	Survey Type[c]	Survey Date(s)[d]	Source of Data[e]
Fairview Creek	T-ROW	3	0	3(0)	RTE	93/02/24-93/02/26	2,3,5
Fish Creek	not mapped	0	1	(1)	INC	92/09/date unspecified	1
	NE 1/4 Section 3	42	0	42(0)	RTE	93/03/23-93/03/26	1,3,5
Hill Creek	T-ROW	2	0	2(0)	RTE	93/02/24-93/02-26	2,3,4,5
Lemolo No. 2	along Mill Creek	1	0	1(0)	RTE	93/03/23-93/03/26	1,3,5
	Upper Mountain Meadows	32	0	32(0)	RTE	93/03/23-93/03/26	1,3,5
	Pond nr Alvin Creek	0	1	0(1)	RTE	93/03/23-93/03/26	1,3,5
Medicine Creek	at road intersection	?	?	?	UNK	not specified	3
Ranawapiti Pond	not applicable	?	?	?	UNK	not specified	3
Secondary Study Area	not specified	37	0	37(0)	INC	93/03/23-93/03/26	1,5
	not specified	0	1	(1)	INC	93/03/23-93/03/26	1,5
	Totals	117	3	117(3)			

[a] Life stage categories are mutually exclusive. Equivalent categories data sources are: egg = egg mass, postmetamorph = AFY or adult or juvenile. A question mark (?) means that category could be present because no category was specified, only map data were available. For eggs, counts are of egg masses, not individuals.
[b] Observations is used to mean the number of individuals observed. Because egg masses do not represent counts of individuals, egg mass counts and counts of postmetamorphs (parentheses) were separated.
[c] Survey types are: incidental observations (INC); rare, threatened, and endangerered species surveys (RTE); and basis of data unknown (UNK).
[d] Actual survey for a given site may not include all days within the indicated interval.
[e] Data sources are: (1) Pacificorp (1995b: Appendix 4.2-1, pp. 3-4); (2) Pacificorp (1995e: Appendix 3-1, Section 7, pp. 7-1 to 7-52); (3) Pacificorp (1995b: Appendix 4.2-4, Map Sheets 2,3,5,6); (4) Pacificorp (1995a: Appendix 4.1, pp. 4-37 to 4-38); (5) Pacificorp (1995a: Appendix 4.1, p. 4-28).

was observed at only three sites in the Primary Study Area, and was significant at only two of these sites. No evidence of northern red-legged frog reproduction was observed in any of the diversions, impoundments, or reservoirs on the NUHP. Some life stages of the northern red-legged frog may have been entrained into various canals, but this cannot be determined because the entrainment studies did not distinguish among species of ranid frogs (Table 9). This species is vulnerable to fish predation when reproduction occurs in permanent water with fishes (Hayes and Jennings 1988), so this alternative may be partly confounded with the possibility that this species could not reproduce successfully in NUHP stillwater sites that have fish.

Cascades frog *(Rana cascadae)*: The cascades frog was the most frequently recorded amphibian of any kind during relicensing studies. Over 1,467 observations of cascade frog life stages excluding egg masses were made and 85 egg masses attributed to this species were found (Table 10). Evidence of significant reproduction (> 10 egg masses or ≥ 100 larvae) at 10 sites, six of which were in the Primary Study Area. Of these six, four were associated with fringe areas isolated from Lemolo Lake, one was associated with Stump Lake, and the remaining one was in Upper Mountain Meadows. Lesser evidence of reproduction (≤ 50 larvae and ≤ 3 egg masses) was observed at eight other sites, all to varying degrees near the Lemolo No. 2 canal. Stump Lake was the only diversion in which the cascades frog reproduced on the NUHP. Some life stages of the cascades frog may have been entrained into various canals, but this cannot be determined because entrainment studies did not distinguish among ranid frog species (Table 9). Like northern red-legged frogs, this species may be vulnerable to predation if reproduction is attempted in permanent water that harbors fishes, so fishes may contribute to this species being unable to reproduce successfully in NUHP stillwater sites.

Bullfrog *(Rana catesbeiana)*: The only data on the bullfrog from the relicensing studies is based on the comment that adults and juveniles of this species were abundant at two of the seven sites at which the western pond turtle was found (Pacificorp 1995a: p. 4-39). Bullfrogs were not recorded from Toketee Lake and presumably, although it was not specified, were observed within the Primary Study Area only in ponds where western pond turtles were observed in association with the transmission line right-of-way. As a consequence, bullfrogs were absent from aquatic systems within the project area above the Soda Springs diversion unless some of the ambiguous ranid frog observations are this species (Table 9). The latter is unlikely based on where these observations were made and what native ranid frogs were found nearby.

Rough-skinned Newt *(Taricha granulosa)*: Data on the rough-skinned newt are based on few observations: at least 15 individuals found at five sites (Table 4). The estimate is imprecise because of the 30 unidentified amphibians obtained during the entrainment studies. Two-thirds (n = 10) of the rough-skinned newts were found during the fish entrainment studies, and seven of these came from the Slide Creek Canal, implying a nearby source. Of the remaining five individuals, one was observed terrestrially in Upper Slide Creek, and the other four were found in the Soda Spring Development. The rough-skinned newt is frequently the most abundant pond salamander in western Oregon (Nussbaum et al. 1983). Unlike other salamander species, adults are visible, rather than cryptic, so the few individuals found during relicensing sampling efforts is notable, in particular because most individuals were recorded from the entrainment studies. Like the long-toed salamander, larval rough-skinned newts can be vulnerable to fish predation, so the few observations of this often common species may reflect a fish effect. The low number of individuals is unlikely to be attributable to a habitat-related elevation effect because this species is common in many high (≥4,500 ft) Cascade lakes west of the crest (Nussbaum et al. 1983).

Table 9. Ambiguous ranid frog observations based on NUHP relicensing application data

General Area	Specific Location	Life Stage[a] Eggs	Postmetamorph	Total Observations[b]	Survey Type[c]	Survey Date(s)[d]	Source of Data[e]
Clearwater No. 1 Canal	not applicable	?	?	7	FES	93/04/14-94/12/19	2
Lemolo No. 1	not specified	2	0	2(0)	INC	93/03/23-93/03/26	1,3
Lemolo No. 1 Canal	not applicable	?	?	4	FES	93/04/11-94/12/10	2
Lemolo No. 2	not specified	2	0	2(0)	RTE	93/03/23-93/03/26	1
Lemolo No. 2 Canal	not applicable	?	?	1	FES	93/07/07-94/12/10	2
Oak Flats	T-ROW, NE 1/4 Section 25	3	0	3(0)	RTE	93/03/23-93/03/26	1,4
	T-ROW, SW 1/4 Section 30	2	0	2(0)	RTE	93/03/23-93/03/26	1,4
Slide Creek Canal	not applicable	?	?	1	FES	93/07/21-94/12/10	2
Soda Springs	above Powerhouse	1	0	1(0)	RTE	93/03/23-93/03/26	1,4,5

[a] Life stage categories are mutually exclusive. Equivalent categories data sources are: egg = egg mass, postmetamorph = AFY or adult or juvenile. A question mark (?) means that category could be present because no category was specified, only map data were available. For eggs, the count refers to the number of egg masses, not the number of individuals.

[b] Observations is used to mean the number of individuals observed. Because egg masses were not based on a count of individuals, the number of eggs mass and the number of postmetamorphs are separated. Where only one number is provided, it represents a count of individuals.

[c] Survey types are: fish entrainment studies (FES); incidental observations (INC); and rare, threatened, and endangered species surveys (RTE).

[d] Actual survey for a given site may not include all days within the indicated interval.

[e] Data sources are: (1) Pacificorp (1995b: Appendix 4.2-1, pp. 7); (2) Pacificorp (1995e: Appendix 3-1, Section 7, pp. 7-1 to 7-52); (3) Pacificorp (1995a: Table 5.3-1, p. 5-21); (4) Pacificorp (1995b: Appendix 4.2-4, Map Sheets 2,3,5,6); and (5) Pacificorp (1995a: Table 5.3-8, p. 5-76).

Table 10. Cascades frog *(Rana cascadae)* observations based on NUHP relicensing application data

General Area	Specific Location	Life Stage[a]			Total Observations[b]	Survey Type[c]	Survey Date(s)[d]	Source of Data[e]
		Eggs	Larvae	Postmetamorph				
Clearwater No. 1	Stump Lake	25	0	0	25(0)	RTE	93/04/27-93/04/30	1,2
	Stump Lake	0	1	0	0(1)	SEA	93/08/date unspecified	1,2
Fish Creek	SE 1/4 Section 3	0	0	1	0(1)	RTE	93/04/27-93/04/30	1,2,3
	along waterway	0	0	1	0(1)	INC	93/06/date unspecified	1,3
	Camas Creek	0	0	1	0(1)	AMP	93/07/19	3,4
Fallen Mountain Creek	not specified	0	0	11	0(11)	AMP	93/07/15	3,4
Lemolo No. 1	not specified	0	0	1	0(1)	UNK	93/05/date unspecified	1,3
	not specified	16	0	0	16(0)	RTE	93/04/27-93/04/30	1,3
	not specified	0	≈100	0	0(≈100)	INC	93/05/date unspecified	1,2,3
	not specified	0	≈100	0	0(≈100)	INC	93/07/date unspecified	1,3
	not specified	0	≈100	0	0(≈100)	INC	93/08/date unspecified	1,3
Lemolo No. 2	not specified	0	≈200	0	0(≈200)	INC	93/04/date unspecified	1,3
	not specified	0	0	1	0(1)	RTE	93/04/27-93/04/30	1,2,3
	not specified	0	≈50	0	0(≈50)	INC	93/05/date unspecified	1,3
	not specified	0	≈50	0	0(≈50)	INC	93/05/date unspecified	1,3
	not specified	0	1	0	0(1)	INC	93/05/date unspecified	1,3
	not specified	0	0	1	0(1)	INC	93/05/date unspecified	1,3
	not specified	0	≈50	0	0(≈50)	RTE	93/06/date unspecified	1,3
	not specified	0	2	0	0(2)	RTE	93/06/date unspecified	1,3
	not specified	0	≈50	0	0(≈50)	RTE	93/06/date unspecified	1,3
	not specified	0	0	1	0(1)	RTE	93/06/date unspecified	1,3

[a] Life stage categories are mutually exclusive. Equivalent categories data sources are: egg = egg mass, larvae = YOY, postmetamorph = AFY or adult or juvenile. A question mark (?) means that category could be present because no category was specified, only map data were available. For eggs, counts are of egg masses, not individuals.

[b] Observations is used to mean the number of individuals observed. Because egg masses do not represent counts of individuals, egg mass counts and counts of larvae + postmetamorphs (parentheses) were separated. For resurveyed areas, observations may represent resighted individuals.

[c] Survey types are: amphibian surveys (AMP), incidental observations (INC); rare, threatened, and endangerered species surveys (RTE); and basis of data unknown (UNK).

[d] Actual survey for a given site may not include all days within the indicated interval.

[e] Data sources are: (1) Pacificorp (1995b: Appendix 4.2-1, pp. 4-6); (2) Pacificorp (1995a: Appendix 4.1, p. 4-28); (3) Pacificorp (1995b: Appendix 4.2-4, Map Sheets 5,6,7); (4) Pacificorp (1995b: Appendix 5.3-5, pp. 1).

Table 10. Cascades frog *(Rana cascadae)* observations based on NUHP relicensing application data (continued)

General Area	Specific Location	Life Stage[a] Eggs	Larvae	Postmetamorph	Total Observations[b]	Survey Type[c]	Survey Date(s)[d]	Source of Data[e]
Lemolo No. 2	not specified	0	1	0	0(1)	INC	93/08/date unspecified	1,3
	not specified	0	0	1	0(1)	SEA	93/08/date unspecified	1,3
	not specified	2	0	0	2(0)	INC	93/04/date unspecified	1,3
	not specified	2	0	0	2(0)	RTE	93/04/27-93/04/30	1,3
	not specified	3	0	0	3(0)	RTE	93/04/27-93/04/30	1,3
	not specified	0	0	1	0(1)	RTE	93/04/27-93/04/30	1,3
	not specified	0	0	1	0(1)	INC	93/04/date unspecified	1,3
	not specified	0	1	1	0(2)	INC	93/05/date unspecified	1,3
	not specified	0	0	1	0(1)	INC	93/05/date unspecified	1,3
	not specified	0	0	1	0(1)	INC	93/05/date unspecified	1,3
North Umpqua River	above Steamboat Creek	0	0	1	0(1)	INC	93/07/date unspecified	1,3
Slide Creek	Upper	0	0	15	0(15)	RTE	93/07/13-93/07/19	1,3,4
	Upper	0	0	4	0(4)	SEA	93/06/date unspecified	1,3
	Upper	0	0	9	0(9)	AMP	93/07/13-93/07/19	4
White Mule Creek	not specified	0	0	1	0(1)	AMP	93/07/12	1,3,4
Secondary Study Area	not specified	37	0	0	37(0)	INC	93/03/23-93/03/26	1,3
	not specified	0	0	1	0(1)	INC	93/05/date unspecified	1,3
	not specified	0	≈500	1	0(≈501)	INC	93/05/date unspecified	1,3
	not specified	0	≈100	0	0(≈100)	INC	93/06/date unspecified	1,3
	not specified	0	≈100	0	0(≈100)	INC	93/06/date unspecified	1,3
	not specified	0	0	1	0(1)	INC	93/06/date unspecified	1,3
	not specified	0	0	1	0(1)	RTE	93/07/date unspecified	1,3

[a] Life stage categories are mutually exclusive. Equivalent categories data sources are: egg = egg mass, larvae = YOY, postmetamorph = AFY or adult or juvenile. A question mark (?) means that category could be present because no category was specified, only map data were available. For eggs, counts are of egg masses, not individuals.

[b] Observations is used to mean the number of individuals observed. Because egg masses do not represent counts of individuals, egg mass counts and counts of larvae + postmetamorphs (parentheses) were separated. For resurveyed areas, observations may represent resighted individuals.

[c] Survey types are: incidental observations (INC); rare, threatened, and endangerered species surveys (RTE); and basis of data unknown (UNK).

[d] Actual survey for a given site may not include all days within the indicated interval.

[e] Data sources are: (1) Pacificorp (1995b: Appendix 4.2-1, pp. 4-6); (2) Pacificorp (1995a: Appendix 4.1, p. 4-28); (3) Pacificorp (1995b: Appendix 4.2-4, Map Sheets 5,6,7); (4) Pacificorp (1995a: Appendix 5.3-5, pp. 1).

Table 10. Cascades frog *(Rana cascadae)* observations based on NUHP relicensing application data (continued)

General Area	Specific Location	Life Stage[a] Eggs	Larvae	Postmetamorph	Total Observations[b]	Survey Type[c]	Survey Date(s)[d]	Source of Data[e]
Secondary Study Area	not specified	0	0	1	0(1)	RTE	93/07/date unspecified	1,3
	not specified	0	0	1	0(1)	RTE	93/07/date unspecified	1,3
	not specified	0	0	1	0(1)	INC	93/07/date unspecified	1,3
	Totals	85	≈1406	61	85(≈1467)			

[a] Life stage categories are mutually exclusive. Equivalent categories data sources are: egg = egg mass, larvae = YOY, postmetamorph = AFY or adult or juvenile. A question mark (?) means that category could be present because no category was specified, only map data were available. For eggs, counts are of egg masses, not individuals.

[b] Observations is used to mean the number of individuals observed. Because egg masses do not represent counts of individuals, egg mass counts and counts of larvae + postmetamorphs (parentheses) were separated.

[c] Survey types are: incidental observations (INC); rare, threatened, and endangerered species surveys (RTE); and basis of data unknown (UNK).

[d] Actual survey for a given site may not include all days within the indicated interval.

[e] Data sources are: (1) Pacificorp (1995b: Appendix 4.2-1, pp. 4-6); (2) Pacificorp (1995a: Appendix 4.1, p. 4-28); (3) Pacificorp (1995b: Appendix 4.2-4, Map Sheets 5,6,7); (4) Pacificorp (1995b: Appendix 5.3-5, pp. 1).

Terrestrial Species

Clouded salamander *(Aneides ferreus)*: Clouded salamander data are based on few observations: at least 17 individuals observed in two areas (Fish and Slide Creeks; Table 11). The number is an estimate because some of 30 amphibians not identified during the fish entrainment studies may represent clouded salamanders. Few clouded salamanders likely reflects no search time being spent in suitable terrestrial habitat for this species (see Appendix) during the appropriate time window (late March-late April). Most individuals of this species were located under pieces of loose bark in association with large woody debris (Pacificorp 1995a: p. 4-41).

Ensatina *(Ensatina eschscholtzii)*: Ensatina data are based on few observations: at least 4 individuals observed in three areas (Watson Creek and two powerline route locations associated with previously proposed diversions; Table 11). The number is an estimate because some of 30 unidentified amphibians obtained during the entrainment studies may represent ensatina. The data are likely to underestimate the extent to which this species occurs within the project area as ensatina was not recorded on some surveys (e.g., RTE surveys), and it is frequently the most common ground-dwelling terrestrial salamander in western Oregon (Nussbaum et al. 1983).

Dunn's salamander *(Plethodon dunni)*: No Dunn's salamanders were observed during relicensing studies (Pacificorp 1995a, 1995b), including the entrainment studies (Pacificorp 1995e: Section 7, pp. 7-1 to 7-52). This species may have been among the 30 unidentified amphibians recorded during the entrainment studies, because the protocol for surveys in the relicensing studies did not emphasize examining its focal habitat (interstitial areas among rocks along stream margins; see Appendix), this species may not have been detected for this reason. Alternatively, this species is near the upper limit of its elevational range in the project area, so may be rare or absent in this area.

Western red-backed salamander *(Plethodon vehiculum)*: Red-backed salamander data are based on few observations: at least 8 individuals observed in two locations (Table 11). The number is an estimate because some of the 30 unidentified amphibians obtained during the entrainment studies may represent western red-backed salamanders. Four of the five individuals were observed in forest talus on Upper Slide Creek, whereas the remaining individual was found in a fyke net in the Clearwater No. 1 Canal during the entrainment studies. The data are likely to underestimate the extent to which this species occurs within the project area as it was not recorded on some surveys that addressed other amphibians (e.g., RTE surveys), and the protocol for surveys in relicensing studies did not emphasize examination of its focal habitat, forested talus.

Discussion

Determination of whether western pond turtles and various amphibian species simply occur within the NUHP-influenced area was basic to Pacificorp's "responsible environmental stewardship while balancing interests of customers and shareholders" (Pacificorp 1995j). Surveys were considered adequate to detect a given species if they attempted to address the focal habitat of that species during an appropriate seasonal interval for a reasonable amount of time. The latter was species-dependent since species-specific survey approaches differ. Based on these criteria, surveys were adequate to detect the western pond turtle and most species of amphibians. Three species may not have been detected because surveys in the focal habitat were fragmentary (i.e., foothill yellow-legged frog) or not directly addressed (i.e., southern seep salamander, Dunn's salamander). However, occurrence of these three species within the NUHP area[7] would represent geographic range-margin conditions, so survey limitations are confounded with the actual potential absence of said species because of some aspect of habitat limitation within the NUHP area. Distinguishing between these

[7] This implies the Primary Study Area, as defined in the NUHP relicensing studies (see Pacificorp 1995b).

Table 11. Terrestrial salamander observations based on NUHP relicensing application data

General Area	Tributary or subunit	Life Stage[a] Juveniles	Adults	Unknown	Total Observations[b]	Survey Type[c]	Survey Date(s)	Source of Data[d]
Clouded Salamander *(Aneides ferreus)*								
Fish Creek	Eva Creek	0	1	0	1	AMP	93/07/19	1,2
Slide Creek	Upper	0	7	0	7	AMP	93/07/13-93/07/19[e]	1,2,3,4
	Upper	3	4	1	8	RTE	93/07/date unspecified	1,2,3
	Upper	1	0	0	1	SEA	93/08/date unspecified	1,2,3,5
	Totals	4	12	1	17			
Ensatina *(Ensatina eschscholtzii)*								
Warm Springs Creek	P-line route	?	?	1	1	SEA	93/spring/date unspecified	5
	P-line route	?	?	1	1	INC	93/spring/date unspecified	5
Watson Creek	not specified	?	?	2	2	UNK	date unspecified	6
	Totals	?	?	4	4			
Western Red-backed Salamander *(Plethodon vehiculum)*								
Clearwater No. 1 Canal	not applicable	?	?	1	1	FES	93/04/14-94/12/19[e]	7
Medicine Creek	not applicable	0	3	0	3	AMP	93/07/21	1
Slide Creek	Upper	0	4	0	4	AMP	93/07/13-93/07/19[e]	1,4
	Totals	?	7	1	8			

[a] Life stage categories are mutually exclusive. Equivalent category data sources are: juveniles = YOY, adults = AFY or adult. A question mark (?) by itself means that category could be represent because a category was not specified, all individuals are unknown.

[b] Observations is used to mean the number of individuals observed. In cases where different surveys were made of the same locality, individuals may have been resighted.

[c] Survey types are: amphibian surveys (AMP); fish entrainment studies (FES); rare, threatened, and endangered species surveys (RTE), seasonal surveys (SEA), and basis of data unknown (UNK).

[d] Data sources are: (1) Pacificorp (1995b: Appendix 5.3-5); (2) Pacificorp (1995b: Appendix 4.2-1, pp. 1); (3) Pacificorp (1995b: Appendix 4.2-5, Map Sheets 5 and 6); (4) Pacificorp (1995a: Table 5.3-13, p. 5-94); (5) Pacificorp (1995a: Table 5.3-10); (6) Pacificorp (1995b: Appendix 5.3-3, p. 1); (7) Pacificorp (1995e: Appendix 3-1, Section 7, pp. 7-1 to 7-52).

[e] Sampling did not include all days within the indicated interval.

alternatives is crucial for the foothill yellow-legged frog, a state-sensitive species, because whether or not it is present may be directly linked to downstream water-flows influenced by the NUHP. Similarly, adequate effort is needed to address whether the southern seep salamander, another state-sensitive species, may be present because NUHP interrupting the flow of lateral tributaries (e.g., Lemolo No. 2 canal interception of small first- or second-order streams that feed seeps) may directly affect habitat potentially used by this species.

Pacificorp (1995j: p. 10) recognizes that, "Natural resource and ecosystem understanding has changed since project construction," and that part of its commitment "to incorporating changed values in developing its license application" has been to provide dispersion data for amphibians and the western pond turtle to help assess local landscape-level issues for these species within the NUHP area. Surveys were judged adequate to define dispersion of a species if they provided a regional understanding of the species' distribution within the NUHP area. For most species for which the focal habitat was surveyed, existing surveys provided an understanding of dispersion across existing or proposed NUHP elements and facilities. However, they could not provide a regional understanding of species dispersion across the NUHP area because surveys were rarely conducted outside NUHP elements and facilities, existing or proposed. The NUHP data that most closely approached providing a regional understanding of species dispersion were those for the cascades and northern red-legged frogs, which was likely related to the ease with which these species could be found and sufficient habitat for these species existing within the primary study area. In contrast, regional understanding of the dispersion of some terrestrial and flowing-water amphibians is lacking because little or no suitable habitat was surveyed for each of these species. The limitations of surveys for the flowing-water species, southern seep salamander and foothill yellow-legged frog, have already been addressed. Surveys for terrestrial amphibians were deficient because little non-riparian terrestrial habitat was examined, and seasonally, timing was suboptimal to detect terrestrial amphibians. Canals (or waterways) have the potential to fragment the terrestrial habitat that such amphibians use. Thus, understanding whether species like the state-sensitive clouded salamander occur in terrestrial habitats next to both sides of the canal systems at different points is fundamental to assessing whether potential for fragmentation by the canal system exists. For most cases of survey inadequacy except perhaps for some terrestrial amphibians, an absence of a species from one or more portions of the NUHP region is confounded with one or more potential habitat limitations that could potentially explain the species' absence. In needs emphasis that surveys must be adequate to provide a reasonable level of confidence that the absence of a species is related to habitat limitation.

The NUHP amphibian data has deficiencies on a regional level, but the data from NUHP elements and facilities, existing or previously proposed, reveal patterns that suggest that exotic fishes negatively impact amphibians in this system. These patterns include:

1) Isolated reproduction in palatable amphibians: Amphibians with palatable larval stages (Pacific chorus frog, cascades frog, northern red-legged frog, long-toed salamander, rough-skinned newt) displayed little or no evidence of reproduction within NUHP facilities in which exotic fish were found. In the few instances in which reproduction in these amphibians was associated with a project facility (e.g., cascades frog), it was either in a small aquatic habitat isolated from the reservoir or on a shallow, protected marginal shelf. As noted previously, lack of the long-toed salamanders is especially peculiar as this species is often common (relative to other species of salamanders; Nussbaum et al. 1983) and the NUHP area is not a range-margin situation for this species. However, this species is known to be especially vulnerable to fish predation (Liss and Larson 1991, Hayes 1995).

2) Non-isolated reproduction in unpalatable amphibians: Amphibians with unpalatable larval stages (northwestern salamander, western toad) are the only amphibians that displayed significant reproduction in NUHP diversions or impoundments in which

exotic fish were found. Both have unpalatable or toxic larval stages (see Appendix), and both have been shown to reproduce in systems to which brook trout have been introduced (Liss and Larson 1991, Hayes 1995). In the NUHP, reproduction in western toad was observed only at Stump Lake, likely because this diversion offers the relatively stable, shallow-water shelf this species requires for reproduction. By contrast, the northwestern salamander, which typically submerges an egg mass in deeper water, reproduced in at least some impoundments subject to ramping.

These patterns imply that for palatable amphibians, the NUHP could be a population sink. Entrainment studies show that several species amphibians can be funneled into the NUHP canal system, including most individuals of at least one species (rough-skinned newt) that was infrequently recorded in the region, so understanding the importance of such a sink to amphibian populations in the region is not a trivial consideration. The lack of observations of the long-toed salamander may reflect this sink.

The entrainment study, designed for fishes (Pacificorp 1995e: 7-1), revealed little regarding amphibians. Several species have the potential to be entrained. Entrainment study fyke nets were not designed to capture amphibian life stages. The 0.75-in (1.9 cm) mesh of the cod ends of the nets would be large enough to let the larvae and postmetamorphic stages of most native amphibians escape unless other debris in the net helped prevent it. Larval tailed frogs can negotiate a significant current (greater than that found in NUHP canals), but their adhesive mouthparts cannot grasp non-smooth surfaces very effectively, so they would be unlikely to grasp the fyke net's flexible netting. Metamorphosed amphibians, unlike fish, would typically not approach the net underwater; upon meeting the net at the water surface, they could simply climb through or over it. As a consequence, most entrained amphibian life stages were probably not held up by the nets. Unless individuals are of a life stage that would allow them to climb out of the canal in a relatively short time, palatable amphibians not captured in fyke nets likely have little chance of survival[8]. The habitat such amphibians use typically has few or no fish and a complex substrate cover, so individuals entrained in canals would be vulnerable to predation even before they reach an impoundment. Even if individuals reach the impoundment, the structurally relatively barren aquatic habitat with fish would also make them vulnerable to predation. What the entrainment study did show was that Stump Lake may be a source of entrained stillwater species (e.g., western toads, northwestern salamanders); and that tailed frog life stages may be entrained from several of the permanent streams that the NUHP canal system intercepts. What the study was unable to identify is the number of amphibians that may have stumbled into the canal at different points within the up to 91 m (300 ft) between each fyke net and the immediately upstream impoundment (rather than being entrained from that impoundment)[9]. If that number is even a small proportion of the individuals caught in the nets, estimates of amphibians caught in canals could be much larger because the estimate would be multiplied over the canal length below which no trap was present.

[8] Pacificorp (1995e: p. 7-52) states that, "Once entrained, most amphibians could probably escape the canals by swimming to the edge of a gunite[sic]-lined section and climbing out." This would assume that the life stage involved is postmetamorphic, that a gunnite section of canal is near enough that individuals would not fall prey to fish in the canal first, and that the amphibians involved would be strong enough swimmers to successful negotiate a current of the magnitude found in the canals and reach the edge to be able to climb out. Pacificorp did not present data to demonstrate that this is the case. Moreover, with the exception of the foothill yellow-legged frog and the tailed frog, postmetamorphic stages of both stillwater and flowing-water breeding amphibians are not strong swimmers in a current. Most would be unlikely to successfully swim against a current of the magnitude typically found in NUHP canals and waterways. Of these two exceptions, only the tailed frog is recorded above Soda Springs.

[9] This is equivalent of entrapment as defined in the wildlife crossing/escape studies (Pacificorp 1995a: Section 6.0, p. 6-1 to 6-36), but it is unknown what proportion of amphibians that stumble into canals may escape and under what circumstances.

Pacificorp (1995a) recognized the importance of terrestrial habitat connectivity to wildlife in its placement of bridges across canals and in assessing the use of bridges through wildlife crossing studies. These studies were evaluated for attempts to address amphibians and the western pond turtle[10]. Wildlife crossing and escape studies evaluated primarily deer and elk (Pacificorp 1995a: pp. 6-1 to 6-36; 1995b: 1994 Addendum, pp. 45-49). Although not clearly specified, the text implies that the open category "other" in the tables summarizing wildlife and footbridge use (Pacificorp 1995a: Table 6.3-4, pp. 6-18 to 6-20; Pacificorp 1995b: Table 6.1-1, pp. 47-49) refers to coyote, black bear, mountain lion, and various smaller mammals, including chipmunk, a mustelid identified as possibly marten, rabbits, raccoon, and squirrels. Although wildlife crossing studies represent a substantial effort to address big game and, to a lesser degree, other mammals, amphibians or western pond turtles were not addressed, nor was the wildlife crossing issue as it relates to these species addressed elsewhere in NUHP terrestrial or aquatic studies (Pacificorp 1995a, 1995b, 1995c, 1995d, 1995e, 1995f, 1995g).

Existing wildlife crossing bridges allow big game and other mammals to cross canals and waterways, but may inhibit amphibian movement for one or more of the following reasons. First, the often slightly elevated ends may act as a drift fence and redirect them elsewhere or to potentially entrap them in the canal or waterway. A truncated or slightly elevated end to the bridge platform of as little as 2.5-7.5 cm (1 or 3 inches) is sufficient to redirect amphibians attempting to cross[11]. This condition was observed during the 10 May field evaluation on several bridges over the Lemolo No. 2 canal. Second, wildlife crossing bridges have an open gap of at least several meters at one end because of the maintenance road next to the canal. Open terrestrial gaps of just a few meters have been shown to be inhibitory to crossing by terrestrial salamanders (Rosenberg 1995). Third, wildlife crossing bridges lack some kind of a physical crease to direct individuals to the crossing point. Where road crossings have been designed for amphibians, an undirected crossing, one that lacks a crease directing animals to the crossing has repeatedly been demonstrated to decrease the likelihood with which amphibians will use wildlife bridges (Langton 1989). Lastly, the exposed surfaces of the wildlife bridges would be hostile, either expose amphibians to potential predators or present an absorptive surface except under the wet conditions. Both conditions are inhibitory to amphibian movement (Rosenberg 1995). Evaluation of NUHP bridge use patterns may be especially important for terrestrial amphibians, but may also be important for those stillwater- or flowing water-breeding amphibian species that use nearby terrestrial habitats (e.g., northern red-legged frog).

Connectivity of aquatic habitats is an issue that was addressed for fishes (Pacificorp 1995c, 1995d, 1995e, 1995f, 1995g), but not amphibians. Moreover, amphibians and fishes tend to partition aquatic habitats between smaller, sometimes ephemeral elements for amphibians and larger, permanent elements for fishes. The NUHP relicensing data display that pattern well. One consequence of limited overlap is that aquatic habitat connectivity data for fishes generally has limited application to amphibians. Field review of the NUHP and perusal of project descriptions and maps revealed three major ways connectivity of aquatic habitats for amphibians have a high likelihood of being compromised. These include: (1) interception of the lateral tributaries of larger streams by canals and waterways; (2) presence of culverts that present substantial obstacles; and (3) the presence of exotic fishes in larger streams that support amphibian populations in their lateral tributaries.

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[10] Whether previous literature on wildlife bridges addressed amphibians or the western pond turtle could not be precisely evaluated because one third (n = 5) of the sources quoted in the text (Pacificorp 1995b: Appendix 6.2-1:1-4) were missing from the literature cited section (Pacificorp 1995a: 7-1 to 7-5 for citations). Nevertheless, it is dubious that amphibians or the western pond turtle were addressed in those sources because of the other 10 sources available in the literature cited, all treated deer and elk.

[11] These data are based on the failure of amphibians to enter pitfall traps with a vertical lip of this dimension.

Several NUHP canals and waterways intercept lateral tributaries of larger streams, but this pattern is most prominent along the Clearwater No. 2, the Lemolo No. 2, and Slide Creek canals. Interception has the potential to alter the patterns of amphibian distribution in three ways. First, larval stream-dwelling amphibians exhibit downstream drift, similar to that seen in stream insects (Hynes 1970). Some Pacific giant salamanders and tailed frogs that appeared in entrainment study fyke nets may represent individuals that drifted into canals. Larval stream-dwelling amphibians drifting into canals have a high probability of being lost to predation. Second, postmetamorphic stream-dwelling amphibians display upstream movement (see Appendix accounts for the foothill yellow-legged frog and southern seep salamander), presumably for individuals to regain the location in the stream that has the favorable habitat from which they may have drifted. A reduced or dewatered stream below a canal, and the canal itself may inhibit upstream movement. Drift and upstream movement may be a major way in which sedentary stream-dwelling amphibians (e.g., tailed frog) have for recolonizing lateral tributaries of a larger stream in which the intervening aquatic habitat is less favorable following extirpation in lateral tributaries. Small lateral tributaries are likely to be vulnerable to extirpation events (see Metter 1968). Third, a reduced or dewatered stream can reduce or eliminate the moist, terrestrial stream-edge habitat used by some species (e.g., northern red-legged frog), and isolate the remaining favorable stream-edge habitat (i.e., upstream from the canal or waterway) from downstream areas that have similar habitat.

Pacificorp has attempted to promote both terrestrial and aquatic habitat connectivity with placement of trestles where canals or waterways would intercept some small drainages (Pacificorp 1995a). Several such locations are especially prominent along the Lemolo No. 2 canal. Trestles appear to maintain connectivity through the terrestrial habitat, and also probably do so in the aquatic habitat from upsteam to below the point of the trestle. But trestles are coupled with a culvert beneath the maintenance road immediately downstream that probably interrupts the continuity of the aquatic habitat for some species. Culverts often had sharp gradients because their placement was steep and/or had an overhang at the downstream end that was significant (extended several feet into space). Either condition has the potential of reducing or eliminating upstream access, the latter because the elevated disconnection eliminates a stream-edge pathway and the former because flow velocity may be too great to allow upstream movement through the water stream. These conditions have the potential of impeding or eliminating access to the upper portions of some lateral streams for amphibians that use such areas. This includes stillwater-breeding species that move between sites that have suitable habitat (e.g., cascades frog), stillwater-breeding species that use riparian edges and mesic upland habitats for some of their life history (e.g., northern red-legged frog, rough-skinned newt), and flowing-water species that dwell in lateral streams or their connections (e.g., southern seep salamander, Pacific giant salamander).

Exotic salmonids, in particular the char, brook trout, and brown trout, exist in significant numbers in the larger streams (e.g, North Umpqua and Clearwater Rivers, Fish Creek) that support amphibian populations in their lateral tributaries (Pacificorp 1995c, 1995d, 1995e, 1995f, 1995g). This condition may increase the isolation of such amphibian populations. Isolation of amphibian populations by introduced fishes is an increasingly recognized phenomenon, and may contribute to extirpation of local populations because opportunities to recolonize extirpated isolates are reduced or eliminated (Bradford et al. 1993; Jennings and Hayes 1994). This pattern parallels the condition of aquatic habitats found within the NUHP (see previous discussion). As a consequence, these larger streams may also be sinks for palatable amphibians.

A reasonable probability exists that some effects implicating mechanical habitat isolation as the result of structures associated with the NUHP and biotic isolation as a result of exotic fishes whose populations may be enhanced by the presence of the NUHP are additive in their potentially negative effects on amphibians. Which combination of these effects are

really significant and what their long-term dynamics may be are unknown. However, the failure to record some species (e.g., foothill yellow-legged frog, long-toed salamander), the few observations of elsewhere common species (e.g., rough-skinned newt), the limited number of locations with significant reproduction for species widespread within the NUHP area (e.g., cascades frog), and a predominance of amphibian with unpalatable larval stages in aquatic habitats within the NUHP should signal some concern.

Recommendations

Pacificorp's commitment to "responsible environmental stewardship" is commenable, but its treatment of how the NUHP may influence amphibians is deficient in ~~four~~ five key areas. Reasonable address of these areas is needed for Pacificorp's relicensing application to "be compatible with agency resource plans" and to "advance agency management objectives" (Pacificorp 1995j). These areas are:

First, surveys for three state-sensitive species were insufficient to either determine their presence within the NUHP area or their status within the area. Surveys for the foothill yellow-legged frog and southern seep salamander, two state-sensitive species, were not sufficient to establish that they were not present with some confidence. Confidence in what the status of these amphibians is within the project area is important because NUHP processes are likely to influence the presence of each species. Lastly, surveys for clouded salamander, another state-sensitive species, were not sufficient to determine where this species may occur on the NUHP area, and as a consequence, whether NUHP elements have the potential of fragmenting its habitat. Surveys for these species should suffice to establish their status and provide implementable management recommendations for these species that are concordant with those of co-operating agencies, namely ODFW and USFS.

– add Tailed Frog

Second, the degree of risk that canals and culverts linked to the NUHP pose to amphibians has not been identified. In particular, the risks that need address are those associated with canal interception of creeks as influencing: (1) entrapment of stream-dwelling amphibians or those species following the riparian margins, (2) reduced downstream flows that directly influence habitat for stream-dwelling or riparian-margin species and/or (3) isolate stream-dwelling or riparian margin species in suitable habitat upstream, and (4) the entrainment or entrapment of stillwater-breeding and terrestrial amphibians; and those risks associated with culverts as influencing the movement of stream-dwelling or riparian-margin species. Risk analysis should be habitat-based with linkage to data on various species at risk (Table 12) and should include some evaluation of the level of risk posed by specific NUHP structures.

Third, effectiveness of wildlife crossing bridges over canals for movement of amphibians needs evaluation. Existing wildlife bridges are likely to inhibit amphibian movement, so they should be evaluated against structures less likely to do so. This evaluation should be some kind of a field-based trial that provides some kind of a species-based assessment of the likelihood of crossing by actual amphibian crossings or failures at crossing attempts, and should include some kind of monitoring to gauge effectiveness over time.

Fourth, the risk that exotic fishes may pose to amphibians needs address. Because exotic salmonids and other fishes are now an integral part of the ecosystem in which the NUHP lies, attempting to remove is neither desirable nor practical. Rather, some kind of long-term monitoring should be established to identify the level of risk exotic fishes pose to amphibians under different precipitation and hydroproject-influenced regimes. Monitoring should occur at key locations within the NUHP area that allow identification of potential changes in risk to both key stillwater-breeding and stream-dwelling amphibians with changing conditions. Data from this monitoring should be incorporated into management models that provide options that attempt to minimize the risk exotics pose to amphibians.

Fifth, the effects of flows released below the project have been addressed for fishes, but not for amphibians. Species that may be potentially affected include the foothill yellow-legged frog and Dunn's salamander. Considerations are similar to some of those that

Table 12. Relative vulnerability of amphibians and the western pond turtle occurring within the NUHP Area

Group	Common Name	Vulnerability to[a]: Exotics	AHF	THF	Entrain	Entrap	O
Flowing-water species	1) *Ascaphus truei*	UpH	UpH	UpL	L	M	8
	2) *Dicamptodon tenebrosus*	UpH	UpM	UpL	L	M	5
	3) *Rana boylii*	H	H	UpL	U	U	10
	4) *Rhyacotriton variegatus*	UpH	UpM	UpM	UpL	UpH	9
Stillwater species	1) *Ambystoma gracile*	L	UpL	UpM	H	UpM	3
	2) *Ambystoma macrodactylum*	H	UpL	UpM	H	UpM	9
	3) *Bufo boreas*	L	UpM	UpL	H	UpH	4
	4) *Clemmys marmorata marmorata*	M	UpH	UpH	UpL	UpM	6
	5) *Pseudacris (=Hyla) regilla*	M	UpL	UpL	H	L	1
	6) *Rana aurora aurora*	M	UpM	UpH	M	L	7
	7) *Rana cascadae*	M	UpH	UpM	H	L	5
	8) *Rana catesbeiana*	L	L	L	M	L	2
	9) *Taricha granulosa*	H	UpM	UpM	H	M	6
Terrestrial species	1) *Aneides ferreus*	U	NA	UpH	L	M	4
	2) *Ensatina eschscholtzii*	U	NA	UpH	L	M	3
	3) *Plethodon dunni*	U	NA	UpH	L	M	6
	4) *Plethodon vehiculum*	U	NA	UpH	L	M	3

[a] Vulnerability to: Exotics (meaning the non-native salmonids found within the NUHP area]; AHF = Aquatic habitat fragmentation, THF = Terrestrial habitat fragmentation; Entrain = Entrainment in NUHP canals from impoundments immediately upstream; Entrap = Entrapment as movement into canals from its lateral edges; O = Overall vulnerability rating for the NUHP project area, based on a composite of vulnerability rating to the five categories indicated and probably pattern of occurrence within the NUHP area (common species were less vulnerable than rare ones) on a scale of 1 (least vulnerable) to 10 (most vulnerable). Scores in each categories are: L = low, M = moderate, H = high, U = unknown, NA = not applicable, p = probably [Example: UpM = unknown, but probably moderate vulnerability to [stated condition]]. Assessments of vulnerability, where known are based on aspects of the life history of each species. Assessment of vulnerability to entrainment or entrapment are based on the potentially most vulnerable life stage.

address fishes, including aseasonal increases in flows that have the potential of stranding larvae forms (foothill yellow-legged frog larvae are more susceptible than most salmonid fishes in this regard) or stripping egg masses from cobble, boulder, or bedrock surfaces (see Lind et al. 1996). Perhaps more important, however, is an evaluation of how the historical modification in the range of flow, if any, may have resulted in habitat loss (see Lind et al. 1996). Data from this evaluation should assist designing flow options that minimize risk to amphibians or alternatively, suggest habitat enhancement options that represent effective countermeasures to habitat losses.

Lastly, other considerations exist that are species-specific and are linked to vulnerabilities displayed by respective species. Some of these considerations are seasonal issues or problems that may result from existing conditions in only some years. They include: (1) withdrawals from Fish Creek could detrimentally increase water temperatures for tailed frog in drought years, (2) removal of large woody debris from the margin of diversions (e.g., Stump Lake) known to have breeding populations of western toads that may serve as overwintering sites for this species, (3) loss of nesting habitat for western pond turtles at Tokotee Lake because of manipulation or manicuring of upland habitat for maintenance reasons, and (4) excessive removal of overstory in association with maintenance activities that increases the likelihood that barriers to the movement of terrestrial species will be created. Generic awareness of these considerations should exist, and they should be addressed on a situation by situation basis, as the need arises.

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Appendix

Background Data on Species Discussed
Characteristics and Habitat Requirements

Flowing-Water Species

Tailed Frog *(Ascaphus truei)*

<u>Eggs and embryos</u>: Eggs are unpigmented, heavily yolked, among the largest for North American frogs (ca. 4 mm average diameter; Wright and Wright 1949), and are laid in disorganized strings that adhere to submerged rocks in the swift stream habitat (Adams 1993). Egg masses are rarely found, so most oviposition probably occurs in interstitial spaces among coarse instream substrates or beneath rocks too large to move. Embryos have the narrowest thermal range (5°-18°C [41°-64.4°F]) and the lowest critical thermal maximum of any North American frog (Brown 1975a), and the rate of consumption of oxygen during development is very low (Brown 1977). These features give the tailed frog the slowest rate of development (embryonic) among North America frogs, which may require as much as nine months (oviposition to hatching).

<u>Larvae</u>: Larvae (tadpoles) have their lower lip expanded into a sucker-like disc (Gaige 1920, Gradwell 1973), attach themselves to rocks in turbulent water (Altig and Brodie 1972), and eat diatoms, desmids, filamentous green algae, and conifer pollen for up to nine months of the year (Metter 1964a, Brown 1990). When active, larvae have a diel cycle during which they move to more exposed positions on rocks at night, presumably to feed (Altig and Brodie 1972), whereas most retreat to interstitial areas of the instream substrate during the day. Young larvae like temperatures ≤10°C (50°F), whereas older tadpoles prefer water temperatures >10°C, but avoid temperatures >22°C (71.6°F) and die at water temperatures >30°C (86°F; de Vlaming and Bury 1970). Winter inactivity and low temperature preferenda contribute to slow larval development (Brown 1989). Time required to reach metamorphosis varies from two years at lower elevations and latitudes to four years at higher elevations and latitudes (Ricker and Logier 1935; Metter 1964a, 1967; Brown 1990).

<u>Postmetamorphic stages</u>: Sexual maturity has been estimated to require seven years in an inland population (Montana), but males and females typically first reproduce in their 8th and 9th years, respectively, and may live more than 15 yrs (Daugherty and Sheldon 1982a). Following metamorphosis, tailed frogs exhibited some movement (Daugherty and Sheldon 1982b), and scattered observations away from streams (Slater 1934; Bury and Corn 1988a, 1988b) indicate that immatures move when temperatures are favorable given enough moisture (see Claussen 1973b). By comparison, adults move little and display high site fidelity (Daugherty and Sheldon 1982b). Adults are also sensitive to high temperatures (Metter 1966, Landreth and Ferguson 1967, Welsh 1990) and have a low lethal maximum (23-24°C [73.4°-75.2°F]; Claussen 1973a).

<u>Critical habitat:</u> The swift, low-temperature stream habitat that tailed frogs require (Bury 1968) must be permanent. Ephemeral streams having all other conditions appropriate are unsuitable because larvae must overwinter instream, typically at least twice (Brown 1990). Douglas fir *(Pseudotsuga menziesii)*, coast redwood *(Sequoia sempervirens)*, Sitka spruce *(Picea sitchensis)*, western hemlock *(Tsuga heterophylla)*, and less frequently, ponderosa pine *(Pinus ponderosa)* dominate forest assemblages in which tailed frogs occur. Although not correlated with any specific forest assemblage, recent work has shown that tailed frogs are either recorded more frequently or solely in mature and old-growth stands (Bury 1983; Bury and Corn 1988a, 1988b; Raphael 1988; Welsh and Lind 1988, Corn and Bury 1989; Welsh 1990, 1993) which typically possess the denser, more shaded habitat structure most likely to create the low temperatures and the high water quality conditions that tailed frog

life stages require (Welsh 1990, 1993). Streams that exceed 15°C for significant periods of time are unsuitable reproductive habitat.

Vulnerability: Specialized aspects of tailed frog biology (e.g., low temperature needs of different life stages) that result in long developmental periods and long intervals to replace adults make this species vulnerable (Bury and Corn 1988b). Noble and Putnam (1931) and Metter (1964b) found that the tailed frog disappeared with removal of timber through harvesting or fire, presumably because increased temperatures if enough stream is exposed (Gray and Edington 1969, Brown and Krygier 1970). Structurally similar streams with different temperatures because of differential removal of forest cover during the 1980 Mt. Saint Helens eruption supported significantly different densities of tailed frogs (Hawkins et al. 1988). Deforestation seems to be slightly less detrimental along the immediate coast (Corn and Bury 1989), presumably because the maritime climate maintains a favorable (cooler) temperature regime (Bury 1968).

Significant gradients exist across the geographic range of the tailed frogs directly related to their temperature requirements and the availability of suitable habitat. With increasingly southerly geographic position (warmer, less mesic conditions), tailed frogs become largely restricted to coastal forest (Bury 1968). Similarly, with progressively warmer, more mesic conditions away from coasts, tailed frog populations are increasingly spotty (Bury 1968). In the latter regard, the NUHP is located in the southernmost drainage in which conditions are just mesic enough to allow significant establishment of tailed frog at inland locations (tailed frogs are rare inland at locations to the south, i.e., upper Rogue River and northern California). Conditions in the North Umpqua are less mesic than in the majority of the range of tailed frogs to the north and west, so the tailed frog is anticipated to be more vulnerable to habitat change in this region.

Tailed frogs may also be vulnerable to scouring high water events (Metter 1968).

Pacific giant salamander *(Dicamptodon tenebrosus)*

Eggs and embryos: Pedicelled eggs are in groups of 60-200 are deposited beneath rock, logs, or rocks in submerged nest chambers in flowing water (Nussbaum 1969a). Females tend the eggs until embryos hatch, an interval as long as 200 days (Nussbaum et al. 1983).

Larvae: Recently hatched larvae have enough yolk to growth two to three months without feeding (Nussbaum et al. 1983). The larval period is 18 to 24 months, during which time caddisflies, mayflies, stoneflies, and small crayfish, fishes, and anuran larvae are eaten, depending on larval size (Nussbaum and Clothier 1973). Diet tends to be focused on the concealed fauna that larvae obtain by overturning rocks with their shovel-shaped snouts.

Postmetamorphic stages: Postmetamorphic individuals occupy mesic coniferous forest terrestrial habitats along stream edges, but are rarely observed because they are cryptic and night active (Nussbaum et al. 1983). Surface movement typically takes place during wet intervals.

Critical habitat: Small-to-moderate sized streams with a moderate gradient that are not too cold (i.e., consistently ≤8°C) are the preferred habitat, but this species can range into stillwater situations where localized spring flows and/or high oxygenation conditions exist (Nussbaum et al. 1983). The aquatic habitat must be associated with a mesic terrestrial habitat where individuals are from populations that metamorphose.

Vulnerability: Metamorphosing populations are vulnerable to terrestrial habitat changes, such as forest removal, that makes such habitat less mesic. Larvae may be vulnerable to scouring high water events.

Foothill Yellow-legged Frog *(Rana boylii)*

Eggs and embryos: Eggs are deposited in masses of 300-1200 on the downstream side of cobbles and boulders over which a relatively thin, gentle flow of water exists (Storer 1925, Fitch 1936, Zweifel 1955). The timing of oviposition typically follows the period of high flow discharge resulting from winter rainfall and snowmelt, which results in oviposition usually occurring between late March and early June (Storer 1925, Grinnell et al. 1930, Wright and Wright 1949). Embryos have a critical thermal maximum (CTM) of <26°C (Zweifel 1955), but the precise embryonic CTM for this species is not known.

Larvae: Larvae (= tadpoles) display more dorsoventral flattening, have a more muscular tail fin, and have a larger number of tooth rows than those of most other ranid frogs native to the western United States, features thought to help the larvae of this species in its flowing stream environment (Zweifel 1955). Larvae are often overlooked because they are cryptic against the substrates of rocky pools and riffles in which they occur. Larvae seem to be capable of growing much more rapidly on epiphytic diatoms than other algae, and have been observed to preferentially graze on this algal type (S. Kupferberg, pers. comm.). After oviposition, a minimum of 15 weeks is needed to attain metamorphosis, which typically occurs between July and September (Storer 1925, Jennings 1988). The Oregon garter snake *(Thamnophis hydrophila)* is known to prey more frequently on the larvae than the metamorphosed individuals of this species (M. Jennings, pers. comm.).

Postmetamorphic stages: Upon metamorphosis, juveniles show a marked differential movement in an upstream direction (Twitty et al. 1967) very similar to the compensating mechanism displayed by stream insects that are subject to downstream drift. Two years are thought to be required to reach adult size (Storer 1925). Postmetamorphs probably eat both aquatic and terrestrial insects (Storer 1925, Fitch 1936). Common *(Thamnophis sirtalis)*, and western terrestrial *(Thamnophis elegans)* garter snakes are known to prey more often on metamorphosed than larval foothill yellow-legged frogs.

Critical habitat: Foothill yellow-legged frogs require shallow, flowing water, apparently preferentially in third to sixth order streams that possess at least some cobble-size substrate (Hayes and Jennings 1988, Jennings 1988). This type of habitat provides locations for oviposition (Storer 1925, Fitch 1936, Zweifel 1955) and likely provides significant refuge habitat for larvae and postmetamorphs (Hayes and Jennings 1988, Jennings 1988).

Vulnerability: Foothill yellow-legged frogs are infrequent or absent in habitats where introduced aquatic predators (i.e., various fishes and bullfrogs) are present (Hayes and Jennings 1986, 1988; Kupferberg 1994), probably because their aquatic developmental stages are susceptible to such predators (Grinnell and Storer 1924).

High water conditions are believed to be responsible for the local extirpation of foothill yellow-legged frogs in certain parts of their range (Sweet 1983). Aseasonal water releases from upstream reservoirs can scour egg masses from their oviposition substrates (Lind et al. 1996). Such aseasonal flows also have the potential to strand larval stages in a manner similar to which has been described for fishes (C. Barkhurst, pers. comm.). Modification of the historic seasonal flow regime can result in significant habitat loss because of the loss or reduction of geomorphological process that maintain areas of suitable habitat (i.e., cobble bars, Lind et al. 1996). Decreased waterflows, because of drought or upstream water retention, can force adult frogs to move into permanent pools where they are likely to be more susceptible to predation (see Hayes and Jennings 1988).

Southern seep salamander *(Rhyacotriton variegatus)*

Eggs and embryos: Eggs for this taxon are unknown, but are presumed to be similar to those of the Columbia seep salamander *(Rhyacotriton kezeri)*: large (4.5 mm diameter), pigmentless eggs found in December were unattached among cracks in a saturated sandstone substratum (Nussbaum 1969b). Moreover, if the pattern of oviposition is

similar to the Olympic seep salamander (*Rhyacotriton olympicus;* see Noble and Richards 1932), communal deposition of singly laid, unattached eggs in concealed, water saturated locations with seepage flow are typical. Critical thermal maxima of eggs and embryos are not known but water temperature at nest and other likely reproductive locations has varied between 5°-11°C (Nussbaum and Tait 1977). The embryonic interval is unknown, but based on laboratory-raised individuals, is probably very long, varying between 200 and 300 days.

Larvae: Larvae occupy permanent, cold seepage areas and small (typically first or second order) streams when the water temperature conditions are not significantly different from where eggs are laid. The larval period is lengthy and has been estimated at over two years for a southern seep salamander population in coastal Oregon (Lincoln Co.; Nussbaum and Tait 1977), making the time required to reach metamorphosis from oviposition between 3.0 and 3.5 years. Inland populations that use habitats with a colder winter temperature regime may take longer (4.5 years for the Cascade seep salamander; Nussbaum and Tait 1977). Larvae displayed a significantly higher percentage of upstream movements (Nussbaum and Tait 1977), presumably to offset downstream drift. Larvae are more vagile than adults, suggesting that larval dispersal may be the most likely means of connectivity between populations.

Postmetamorphic stages: Upon metamorphosis, juveniles may require another 3-4 years to reach sexual maturity. Adults are active at air and water temperatures lower than those known for any other aquatic salamander, between 5°C and 10°C (Stebbins and Lowe 1951, Stebbins 1955, Brattstrom 1963; see also Nussbaum and Tait 1977). Southern seep salamanders are probably the most desiccation-intolerant salamanders in the herpetofauna of the Pacific Northwest (see Ray 1958), which is likely related to a heavy dependence on cutaneous respiration for oxygen exchange (Whitford and Hutchinson 1966). Welsh and Lind (1992) suggest that postmetamorphic southern seep salamanders may be sedentary.

Critical habitat: Cold, permanent seeps and small streams with a rocky substrate appear to be the preferred habitats (Fitch 1936, Stebbins and Lowe 1951, Stebbins 1955). Relatively recent work has linked this species to seeps, small streams, and waterfalls in wet or mesic, coastal, old-growth habitats (Bury 1983, Welsh and Lind 1988, Corn and Bury 1989, Good and Wake 1992, Welsh 1993; see also Raphael 1988), an association that is likely influenced by the fact that old-growth provides the hydric and thermal environments more favorable (cooler and wetter) to the survival of southern seep salamanders than similar habitats in non-old growth situations (Welsh 1990).

Vulnerability: Specialized aspects of southern seep salamander biology (e.g., low temperature needs of different life stages) that result in long developmental periods and long intervals to replace adults make this species vulnerable (Bury and Corn 1988b). The vulnerabilities for this species are similar to those of the tailed frog, but more severe because its greater vulnerability to desiccation and the utilization of a breeding habitat that is much more localized. If populations of this species are present in the NUHP area, they would be anticipated to be particularly vulnerable because much of the intervening habitat would not be mesic enough for this species to survive.

Stillwater Species

Northwestern salamander *(Ambystoma gracile)*

Eggs and embryos: Moderate-sized (1.5-2.5 mm diameter) eggs are deposited in firm, globular masses of 40 to 270 on an oviposition brace, which varies from the submerged portion of emergent vegetation to twigs of woody debris (Knudsen 1960, Neish 1971, Snyder 1956). The embryonic interval is 30 to 60 days, depending on egg size and temperature (Brown 1976).

Larvae: Larvae grow at the site of oviposition for two years (overwintering twice) if they metamorphose, or they may become neotenic, in which case they may require an additional year before they reproduce (Nussbaum et al. 1983). Larvae possess toxic parotid and tail glands that improve they survivorship over most other aquatic amphibians where fishes have been introduced (Liss and Larson 1991).

Postmetamorphic stages or neotenes: Metamorphosed individuals occupy mesic terrestrial habitats, and their cryptic and nocturnal behavior results in their being infrequently seen (Nussbaum et al. 1983). Neotenes typically occur in regions where terrestrial habitats are hostile (Sprules 1974). Both metamorphosing individuals and neotenes possess parotid and tail glands that are potently toxic.

Critical habitat: Breeding habitat is cool stillwater at least 0.4 m deep with vegetation or debris on which to deposit eggs (Knudsen 1960, Neish 1971). The breeding and larval habitat must be permanent because larvae either overwinter or become neotenic. For those populations that metamorphose, the terrestrial habitat must be sufficiently mesic to allow survival.

Vulnerabilities: Metamorphosing populations are vulnerable to conditions that make the terrestrial habitat less mesic, such as removal of forest vegetation. Populations can survive where exotic fishes have been introduced, but are more successful where such fishes are absent (Liss and Larson 1991). Metamorphosing populations are also vulnerable to changes in the link between the terrestrial and the aquatic habitat that may affect their movements in either direction.

Long-toed salamander *(Ambystoma macrodactylum)*

Eggs and embryos: Moderate-sized (2.0-2.5 mm diameter) eggs are deposited singly or in small clusters of 4 to 80, either attached to vegetation or different stationary, submerged substrates (Kezer and Farner 1955, Knudsen 1960, Anderson 1967). Embryos hatch two to four weeks following oviposition (Nussbaum et al. 1983).

Larvae: The larval period is highly variable, and may be as short as 50 days or as long as 14 months depending on temperature and elevation (Nussbaum et al. 1983). However, in most environments, larvae metamorphose within the season in which they were laid.

Postmetamorphic stages: Metamorphosed individuals occupy mesic burrows in terrestrial habitats, and their cryptic and nocturnal behavior results in their being infrequently seen (Nussbaum et al. 1983).

Critical habitat: Breeding habitat ranges from ephemeral pools with a hydroperiod of around at least three months to permanent stillwater habitat in which fishes are absent. The adjacent terrestrial habitat must possess mesic subterranean refuge site, usually in the form of mammal burrows.

Vulnerabilities: Long-toed salamanders are intolerant of the presence of introduced fishes, as they are highly vulnerable to predation because of the lack of toxic skin glands (Liss and Larson 1991). As a consequence, they are especially vulnerable in those permanent aquatic habitats to which fishes have been introduced. Long-toed salamanders are also vulnerable to changes in the link between the terrestrial and the aquatic habitat that may affect their movements in either direction.

Boreal or western toad *(Bufo boreas)*

Eggs and embryos: Relatively small (1.5-1.7 mm diameter) eggs are deposited as twin gelatinous strings in masses averaging 12,000 in relatively warm, shallow water (Metter 1961, Samallow 1980). The embryonic interval is short, as hatching typically occurs in six to 12 days.

Larvae: Larvae are contrastingly black and aggregate diurnally in large schools in shallow water. As the larvae possess skin toxins, this coloration and behavior is thought to be an advertisement of the noxious condition (Nussbaum et al. 1983). When available, larvae will select temperatures in the vicinity of 30°C, although such temperatures are not always available, especially in the higher elevation habitats in which this species occurs (O'Hara 1981). Growth is rapid and individuals consistently metamorphose within the season that they were laid as eggs, usually within two months.

Postmetamorphic stages: Recently metamorphosed individuals are typically very small (8-13 mm body length) and occupy terrestrial habitats near an aquatic margin (O'Hara 1981). After a brief interval of growth, juveniles disperse from the natal aquatic margin into surrounding areas. As juveniles grow, they continue to display substantial movement, whereas as these individuals mature, they appear to become more sedentary. However, throughout the postmetamorphic interval, individuals are tied to sources of water, to which they must return at regular intervals for hydration. During dry intervals, burrows are used for aestivation (Nussbaum et al. 1983).

Critical habitat: Breeding habitat consists of permanent, stillwater that has shallow shelves for oviposition and rapid development of larvae (O'Hara 1981). This must be coupled with some sort of terrestrial overwintering refuge. Although the nature of the latter is not well understood, hollow logs with an adequately moist interior substrate (often moist frass) are known to have been used in several instances (M. Hayes, pers. observ.). This species can survive the presence of fishes in its breeding habitat, but like the northwestern salamander, it is more successful where fishes are absent.

Vulnerabilities: Western toads are vulnerable to changes in water level that may alter the breeding or larval habitat (see O'Hara 1981). They are also vulnerable to changes that may result in the alteration or loss of the overwintering site.

Western pond turtle *(Clemmys marmorata)*

Nests and eggs: Females move from the aquatic site to an upland location that may a be considerable distance (400+ m, but often less) and deposit from 1-13 eggs that have a thin, but hard (calcified) outer shell in a shallow (ca. 10-12 cm deep) nest excavated by the female (Holland 1991a; Rathbun et al. 1992, 1993). Most oviposition occurs during May and June (Storer 1930; Buskirk 1992; Rathbun et al. 1992, 1993).

Hatchling, young juveniles, and adults: The young may hatch and overwinter in the nest because hatchling-sized turtles have almost never been observed in an aquatic site during the fall (Holland 1985a). Most hatchling turtles are though to emerge from the nest and move to the aquatic site in the spring (Buskirk 1992). Hatchlings spend much of their time feeding in shallow water that typically has a relatively dense vegetation of submergents or short emergents. The zooplankton fauna that can occur at high densities in standing water are an important food of hatchlings and young juveniles (Holland 1985b, 1991a). Much variation exists in the rates at which western pond turtles grow, with slower growth at higher altitudes and latitudes. Juveniles grow relatively rapidly for the first few years, and in Oregon, the attainment of sexual maturity seems to require well over 10 years (Holland 1994). Adults are potentially long-lived (>40 yrs). Large juveniles and adults use aquatic habitats that are permanent, attain water temperatures consistently >15°C (usually >20°C) during their active season, and possess emergent and water-basking locations and refuges that include some deep-water (≥1.0 m). Turtles also use upland habitat to escape adverse conditions in the aquatic habitat and to overwinter (Rathbun et al. 1992, 1993).

Critical habitat: The western pond turtle requires a composite of aquatic and adjacent upland terrestrial habitats. The aquatic habitat must reach surface water temperatures above 15°C for a significant portion of the active season. Pond turtles are uncommon or absent in high gradient streams probably because water temperatures, current velocity, food resources, or

any combination thereof limits their occurrence (Holland 1991a). Habitat quality seems to vary with the availability of emergent and water basking sites. Emergent basking sites may be especially critical in Oregon, especially at altitude (as in the NUHP area), because water temperatures will be limiting more frequently. Nesting locations should be well-drained and exposed to have sufficiently elevated soil temperatures as excessively moist nest sites have a high probability of failure (Feldman 1982, Holland 1991b). At a relatively high elevation location (like the NUHP area), this means a little-vegetated slope with at least a partial south-facing aspect and a soil with significant clay fraction. Overwintering locations remain poorly characterized, but they should probably ensure that overwintering turtles have a low likelihood of freezing (Holland 1994).

Vulnerabilities: Western pond turtles are probably most vulnerable to local increases in nest site predation over historic background levels and alterations of the nest site that result in recruitment or reproductive failures. Regarding the former, shifts in human activity that result in changes in patterns of raccoon activity, such as localization of refuse containers, have the potential to increase nest predation levels in this manner. Regarding the latter, the incursion of invasive exotic plants, like Scotch broom *(Cytisus scoparius)*, or the existing successional pattern could result in nest site alteration to a point that nests can no longer be successful. Levels of human use can decrease the time turtles spend emergent basking, which could potentially be critical at a high elevation site. Since females spend more time emergent basking to yolk up eggs, this could directly affect reproductive success. All these factors have the potential to be significant if alterations occur at a site like the Stink Hole. Lastly, western pond turtles are vulnerable to predation by warm-water exotics (bullfrogs, basses). Although these species are not currently a problem within the Primary Study Area of the NUHP, efforts should be made ensure that future modifications discourage their establishment.

Pacific chorus frog *(Pseudacris regilla)*

Eggs and embryos: Small (0.7-1.4 mm diameter) eggs in packets of 9 to 70 are deposited in shallow pools attached to vegetation or other submerged, stationary objects (Schaub and Larsen 1978, Nussbaum et al. 1983). Eggs are deposited at water temperatures between 5°C and 10°C; in western Oregon, this means egg deposition date will vary from late January to late June, depending on the annual temperature regime and site elevation. The embryonic interval lasts two to five weeks.

Larvae: Larvae lack significant skin toxins and grow rapidly from a tiny size (6-8 mm) at hatching to a 45-60 mm total length before metamorphosing (Schaub and Larsen 1978, Nussbaum et al. 1983). When available, larvae will select a relatively high (28-30°C) temperature range in shallow water (Brattstrom 1963). Individuals always metamorphose within the season that they were laid as eggs, usually from six weeks to 2.5 months after oviposition (Nussbaum et al. 1983; Hayes, pers. observ.).

Postmetamorphic stages: Recently metamorphosed individuals are typically relatively small (10-15 mm body length) and soon move into terrestrial habitats near an aquatic margin (Jameson 1956, Schaub and Larsen 1978). Juveniles grow rapidly and typically attain an adult size in the same year they were laid as eggs (Jameson 1956). Juveniles and adults move extensively through areas of dense, mesic vegetation. Activity is reduced during hot, dry intervals, burrows and other concealed retreats are used for aestivation (Nussbaum et al. 1983).

Critical habitat: This species will reproduce in almost any freshwater aquatic habitat with adequate water quality (low or no salinity, at least moderate oxygenation) and a long enough hydroperiod to allow metamorphosis to occur (Nussbaum et al. 1983). As a consequence, aquatic habitats ranging from permanent to ephemeral with a hydroperiod of as little as 2.5 months are used for oviposition. Ephemeral oviposition sites are often used, probably because they have a more favorable temperature regime for development, and the

risk of predation from fishes is considerably reduced. This species must also have some sort of terrestrial overwintering refuge, but the restrictions on such a site are limited to the facts that it cannot be too desiccating and it should not expose individuals to hard (<28°C) freezes.

Vulnerabilities: This species is the least vulnerable of the amphibians native to this region. Despite this plasticity, they do poorly in permanent aquatic habitat with limited refuges when faced with fish predation.

Northern red-legged frog *(Rana aurora aurora)*

Eggs and embryos: Northern red-legged frogs have the lowest embryonic critical thermal maximum known (21°C) for any North American ranid frog (Licht 1971), which is likely the reason that oviposition is restricted to a time window early in the year (January-March: Storm 1960, Licht 1969, Brown 1975b). Large (3.0 mm average diameter; Livezey and Wright 1945), pigmented eggs are laid in a rounded, submerged egg mass that contains 200-1100 eggs and is attached to a vegetation brace (Storm 1960, Licht 1969, Brown 1975b). The time for northern red-legged frog embryos to develop to hatching can vary from less than one week (at 20°C) to over eight weeks (at 4.5°C), but embryos typically require 4-5 weeks at field water temperatures of 6-9°C (Storm 1960, Licht 1971).

Larvae: Larvae lack significant skin toxins, are often cryptic and not always easily seen. They appear to display a preference for a light- and dark-striped substrate, which is correlated with their developing in a habitat with a striped light and shade mosaic that results from rooted submergent or emergent vegetation (Wiens 1970). Larvae are algal grazers that can significantly reduce the standing crop of epiphytic algae under certain conditions (Dickman 1968). Individuals are only known to metamorphose within the season that they were laid as eggs, which has required about 3.5 months (Licht 1974, Brown 1975b) at low elevations. Field observations suggest that 4-5 months may be required under a cooler temperature regime (pers. observ.).

Postmetamorphic stages: Juveniles grow rapidly, and males can become sexually mature the breeding season after they metamorphose (Licht 1974), but most do not reproduce until the second breeding season. Females require an another year for maturation, but typically do not reproduce until their third breeding season. After the January-March reproductive interval, adults move into uplands presumably mesic enough for them to obtain moisture from the substrate. A fall activity pulse indicated by an increase in red-legged frogs found on roads after enough soaking fall rains have occurred suggests that adults return to the vicinity of breeding sites at this time (J. Applegarth, pers. comm.). Similar pulses of red-legged frogs have been observed during the fall in one direction of a bidirectional fish trap set along a permanent stream (S. Mamoyac, pers. comm.).

Critical habitat: Northern red-legged frog breeding habitat typically consists of permanent or ephemeral water bordered by dense grassy or shrubby vegetation (Storm 1960, Licht 1969, Calef 1973a, Brown 1975b, Twedt 1993). When ephemeral, standing water is typically available for the life stages of the northern red-legged frog for 4-6 months (see Storm 1960). Postmetamorphic frogs use upland habitat consisting of patches of dense grassy or shrubby vegetation (Stebbins 1951, Storm 1960, Twedt 1993), such as willow or sword fern thickets and dense sedge swales or skunk cabbage marshes or swamps that maintain significant substrate moisture. Habitat linked to beaver *(Castor canadensis)* dams seems to provide all the aforementioned conditions and may be particularly favorable for northern red-legged frogs because they frequently occur in such habitat (see Stebbins 1951 and Brown 1975b).

Vulnerabilities: Northern red-legged frogs are particularly vulnerable to modifications that disconnect the upland habitat used during the active season with the aquatic habitat used for reproduction. Lacking significant skin toxins, northern red-legged frogs are vulnerable to

predation by exotic fishes and bullfrogs in permanent aquatic habitats; larvae and recently metamorphosed life stages are most vulnerable (Twedt 1993).

Cascades frog *(Rana cascadae)*

Eggs and embryos: Cascades frogs deposited rounded egg masses of 400-600 eggs laid in exposed shallow water, unattached to a vegetation brace (Sype 1975). Oviposition occurs sometime in the interval March to July depending on climatic conditions and elevation (Nussbaum et al. 1983). Oviposition is timed so embryos are typically not exposed to water temperatures of ≥28°C, the lethal upper limit (Sype 1975). The time required to develop to hatching varied around about two weeks.

Larvae: After hatching, cascades frog larvae are almost never found alone, but form spatially loose social aggregations of generally <100 individuals composed primarily of kin (O'Hara and Blaustein 1985, Blaustein and O'Hara 1987). Larvae voluntarily select a high water temperature (27.3 ± 0.6°C; Wollmuth et al. 1987), presumably to optimize conditions for growth and development. Length of the larval period is also highly temperature dependent, but probably ranges from one to over two months in the field (Nussbaum et al. 1983, Briggs 1987). Upon entering metamorphosis, larvae select the highest environmental temperatures (28.8 ± 0.4°C) during their developmental history (Wollmuth et al. 1987), presumably to minimize the time spent vulnerable during the metamorphic interval. Larvae lack significant skin toxins, but are not particularly cryptic and can be easily observed.

Postmetamorphic stages: After metamorphosis, all postmetamorphic life stages voluntarily select temperatures <17°C (Wollmuth et al. 1987). Postmetamorphs grow slowly. Based on growth rates of marked individuals, males mature at two years of age, whereas females mature at four years (Briggs and Storm 1970). However, both sexes may not reproduce until they are one or two years older than the minimum ages at maturity. Data from other marked populations indicate that adults typically live 8-12 years (D. Olsen, pers. comm.).

Critical habitat: The cascades frog occurs and reproduces in both ephemeral and permanent ponds or streams (Zweifel 1955, Nussbaum et al. 1983, Briggs 1987), but probably cannot survive in ephemeral situations where at least some of the substrate does not remain saturated. Oviposition habitat is open, shallow water (Briggs 1987) that remains unshaded during the hours of strong sunlight. Aquatic sites in which the cascade frog is found are relatively oligotrophic (Briggs and Storm 1970, Nussbaum et al. 1983), so it may require a higher level of water quality than other ranid frogs. Cascades frogs overwinter underwater or in saturated ground (Briggs 1987), presumably because frogs cannot survive the level of water loss sustained if a dry terrestrial overwintering site were used. Some evidence exists that underwater overwinter sites are associated with upwelling springs that may provide a shelter from freezing conditions (pers. observ.).

Vulnerabilities: Lacking significant skin toxins, cascades frogs typically occur in waters lacking predatory fish and recent data (Hayes 1995) suggest that cascades frogs have shifted away from using permanent aquatic habitats for oviposition even though the post-metamorphic life stages may continue to occupy those habitats because exotic salmonids, especially the char, brook trout *(Salvelinus fontinalis)* occur there. Some evidence exists of population connectivity among local cascades frog populations (O'Hara 1981), so placement of barriers that increasingly disconnect local populations may place these at risk.

Bullfrog *(Rana catesbeiana)*

Eggs and embryos: Bullfrogs deposit very large egg masses of 15,000->70,000 tiny (0.7-0.9 mm diameter) eggs laid in a film on the water surface. Eggs are laid when the surface water has reach at least 20°C. As a consequence, in Oregon, oviposition takes places in the interval late May to July, depending on the annual temperature regime and elevation. In

wetter years and a higher elevations, oviposition occurs later during the indicated interval. Hatching typically occurs in 6-10 days. The eggs and embryos possess repellents that reduce predation by fishes.

Larvae: After hatching, larvae require at least one to two full years before metamorphosis. Thus, larvae must overwinter at least once, and in cooler water conditions and/or at higher elevations, they must overwinter at least twice. Nowhere in Oregon can bullfrog grow fast enough to metamorphose in the same year that they were laid as eggs (pers. observ.). The larvae posses skin toxin repellents that reduce predation by fishes. Metamorphosis occurs at a relatively larger size (30-45 mm body length) than the native ranid frogs in Oregon with which bullfrogs may co-occur.

Postmetamorphic stages: Following metamorphosis, bullfrogs grow to a large, sexually mature size (ca.110-120 mm body length) relatively rapidly. At low elevations, males and females probably average two years to reach this size, whereas more time is require at higher elevations. After reaching a sexually mature size, bullfrogs continue to growth more slowly, and reach a maximum size of between 160 and 200 mm, depending on how long they live and growth conditions at the location where they are found. This maximum size is considerably larger (55-95 mm) than the maximum size of any of the native ranid frogs found in Oregon, our largest native frogs. Unlike native ranid frogs in Oregon, female bullfrogs can multiple clutch. Sufficient time exists in the bullfrog active season for large females to deposit two clutches of eggs in lowland western Oregon, and perhaps three in the southwestern part of the state.

Critical habitat: The larval period of bullfrogs restrict their reproduction to permanent water that warm enough (>20°C surface water temperatures for several months), but beyond this restriction bullfrogs can invade numerous still- and flowing-water habitats, including those that may be too cold for their reproduction. In the latter cases, a warmwater reproductive site within a certain distance can maintain a continuous stream of recruits.

Vulnerabilities: The restriction to warmwater breeding conditions that results in a lengthy larval period is the only significant vulnerable aspect of bullfrog life history. Otherwise, bullfrogs are more resilient than native ranid frogs and other native amphibians in virtually all aspects of their life history. Their size gives them a predatory advantage, they can produce more offspring with greater frequency, they have anti-predator devices that assist in the face of fish predation, and where it has been measured, they have more tolerance to environmental insults than other ranid frogs (e.g., lowered oxygen levels, the application of rotenone, elevated water temperatures). Since most human alterations of habitat tend to increase water temperatures and lower oxygen levels, most changes have favored bullfrogs rather than the native ranid frogs in Oregon and elsewhere in the western United States.

Rough-skinned Newt *(Taricha granulosa)*

Eggs and embryos: Moderate-sized (averaging 1.8 mm diameter) tan and cream eggs are laid singly and attached to the stems, or concealed in the leaves, of submergent vegetation (Oliver and McCurdy 1974, Nussbaum et al. 1983). Eggs hatch in 20 to 26 days.

Larvae: In western Oregon, larvae metamorphose in the same year they were laid as eggs at a relatively small size (25-35 mm body length). Populations near the crest of the Cascades Mountains in southern Oregon are neotenic, probably because at the edge of this species' geographic range, the terrestrial habitat is hostile (Marangio 1978). Larval or neotenic newts lack the skin toxicity of adults.

Postmetamorphic stages or neotenes: Metamorphosed individuals occupy mesic terrestrial habitats and make biannual migrations between aquatic and terrestrial habitats (Nussbaum et al. 1983). Metamorphosed individuals have skin glands that are potently toxic. Even though their dorsal coloration is cryptic, they advertise toxicity when turned over by a predator with the strikingly contrasting orange-yellow ventral coloration and slow, but

deliberate display behaviors that help ensure the warning coloration can be adequately identified. Postmetamorphs require several years to become sexually mature and are probably long-lived.

Critical habitat: Breeding habitat must be permanent because of the return to vicinity of water during the fall, or if individuals are neotenic because they never leave water, and it must possess a vegetated substrate on which to lay eggs. The aquatic breeding habitat must be coupled to adjacent terrestrial habitat. Terrestrial habitat must possess refuges in the form of mammal burrows or large woody debris to serve as retreat sites during dry intervals.

Vulnerabilities: As with other amphibians that move between terrestrial and aquatic habitats, rough-skinned newts are vulnerable to changes that reduce their ability to make the necessary moves between habitats. The terrestrial habitat is vulnerable to xerification from changes that would remove vegetation. Although postmetamorphs are protected from most predators because of their skin toxins, larvae are especially vulnerable to predation where exotic fishes have been introduced (Hayes 1995; see also Liss and Larson 1991).

Terrestrial Species

Clouded salamander *(Aneides ferreus)*

Eggs and embryos: Clouded salamander eggs and nests are known from very few observations. Small groups (n = 8-18) of large (5.0 mm diameter) eggs are suspended from the roofs of cavities in logs or crevices in rocks (Storm 1947, Leonard et al. 1994). Eggs require about 60 days to develop, and based on the appearance of the tiny juveniles, probably typically hatch in the autumn; thus, these eggs are likely laid mid-to-late summer.

Posthatching juveniles and adults: Posthatching clouded salamanders are cryptic and rarely observed at the surface. Even under ideal moisture conditions, they are most often found beneath bark on large pieces of woody debris in intermediate or advanced decay classes or snags. Males and females become sexually mature in one and two years, respectively. Postmetamorphs are excellent climbers, but the full range of microhabitats that this species uses is poorly understood. Clouded salamanders focus on ant, beetle and other terrestrial arthropod prey associated with woody debris (Fitch 1936, Storm and Aller 1947, Bury and Martin 1973, Whitaker et al. 1986).

Critical habitat: Although rock crevices have been speculated to be oviposition sites, all of the few nest descriptions are in cavities in logs, so until alternative nest sites are located, it should be conservatively assumed that large woody debris is necessary for oviposition. If it is not absolutely necessary for oviposition, it appears to be a requirement for the prey resource base that clouded salamanders use. Moreover, field observations indicate that clouded salamanders are much more frequent in conifers with thicker, more robust bark (i.e., Douglas fir) than those with thinner, lighter bark (e.g., western hemlock, grand fir). The former may ensure adequate moisture levels for the salamander as well as its prey base (Whitaker et al. 1986). The observation that this species appears more abundant in stands following burns (Nussbaum et al. 1983) may linked to an enhanced food resource base. That large Douglas fir, with its thicker bark, is more fire resistant, may allow clouded salamanders to survive burns in stands with large Douglas fir and their debris where it might not survive in burned stands dominated by thinner-barked species.

Vulnerabilities: Clouded salamanders may be vulnerable to conditions that reduce or eliminate large woody debris.

Ensatina *(Ensatina eschscholtzii)*

Eggs and embryos: Ensatina eggs and nests are known from few observations. Groups of five to 16 large (4-7 mm diameter), unpigmented eggs are laid in a grape-like cluster on the

floor of either a subterranean or log cavity (Stebbins 1949a, 1949b, 1954). The female tends the eggs, which are typically laid in spring, incubated through summer months, and develop in 150-180 days.

Posthatching juveniles and adults: Posthatching ensatina are cryptic and rarely observed at the surface. Under ideal moisture conditions, they can be seen under a variety of surface objects, including loose wood, under bark on large woody debris, rocks, and other objects. In California, males and females mature in their third year (Stebbins 1954), so attainment of sexual maturity in Oregon may require more time.

Critical habitat: Although ensatina, like other terrestrial salamanders, has a concealed egg deposition site, it appears to be much more flexible in the type of oviposition sites it can use when compared to other terrestrial species. Ensatina seems to require the presence of some woody debris, but neither large woody debris nor conifers appear to be necessary for ensatina to be present.

Vulnerabilities: Ensatina may be vulnerable to conditions that eliminate woody debris.

Dunn's salamander *(Plethodon dunni)*

Eggs and embryos: Dunn's salamander nests are based on a single observation, and data on oviposition are inferred from examining gravid females. The single nest observation was in a deep crevice in shale rock along a stream margin in which nine eggs were found with an attendant female (Dumas 1955). Based on mature ovarian eggs, clutch size is through to vary between four and 15, and egg size is thought to between 4.5 mm and 5.5 mm in diameter. The time required to develop to hatching has been estimated at 70 days (Dumas 1955).

Posthatching juveniles and adults: Posthatching Dunn's salamanders are cryptic and rarely observed at the surface. Under ideal moisture conditions, they can found in the interstitial spaces among rocks in the portion of the stream or waterfall edges moistened by capillarity or spray (Nussbaum et al. 1983).

Critical habitat: Rocky interstitial stream margins appear to be critical habitat, both for this species to reproduce, and for foraging and refuge as it has not be found outside of such habitat. In Oregon, Dunn's salamander is not known about about 1,000 m [3,280 ft], so it is unlikely to occur a great distance into the Primary Study Area of the NUHP. Moreover, this species is spotty in the interior Umpqua because of less mesic conditions along rocky stream margins.

Vulnerabilities: Dunn's salamander may be vulnerable to scour conditions along rocky stream margins.

Western red-backed salamander *(Plethodon vehiculum)*

Eggs and embryos: Western red-backed salamander nests are based on a few observations as well as data inferred from examining gravid females. The few nest observations have been in basaltic rock talus with the eggs attached to rock surfaces (Hanlin et al. 1979). In Oregon, 6 to 19 large (4.0-5.0 mm diameter) are laid. An attendant female probably tends the eggs during development (Hanlin et al. 1979). Based on egg development in females, oviposition probably occurs in spring and eggs are incubated until they hatch in the fall (Peacock and Nussbaum 1973).

Posthatching juveniles and adults: Posthatching western red-backed salamanders are cryptic, but can be seen at the surface under sufficient moisture conditions by moving appropriate surface cover. Under ideal moisture conditions, posthatching salamanders are found in rocky talus with overlying coniferous forest. In coastal situations, coniferous cover may be less important to the temperature microclimate of the moist talus, but at interior (non-coastal) sites, it is probably critical. The NUHP area is such an interior site.

Critical habitat: Rocky interstitial areas that are coniferous cloaked appear to be critical.
Vulnerabilities: Western red-backed salamanders may be vulnerable to conditions that result in coniferous forest removal, especially at interior locations.